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MINERAL RESOURCES

OF THE

UNITED STATES

1918

G. F. LOUGHLIN
Geologist in Charge, Division of Mineral Resources

PART II—NONMETALS

R. W. STONE, Geologist in Charge

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MINERAL RESOURCES OF THE UNITED STATES, 1918—PART II.

FUEL BRIQUETTING.

By C. E. Lesher.

PRODUCTION.

The production of fuel briquets in 1918 was 477,235 net tons, valued at $3,212,793, an increase, compared with 1917, of 70,379 tons, or 17 per cent, in quantity and of $978,905, or nearly 44 per cent, in value. The production in 1918 was the highest recorded

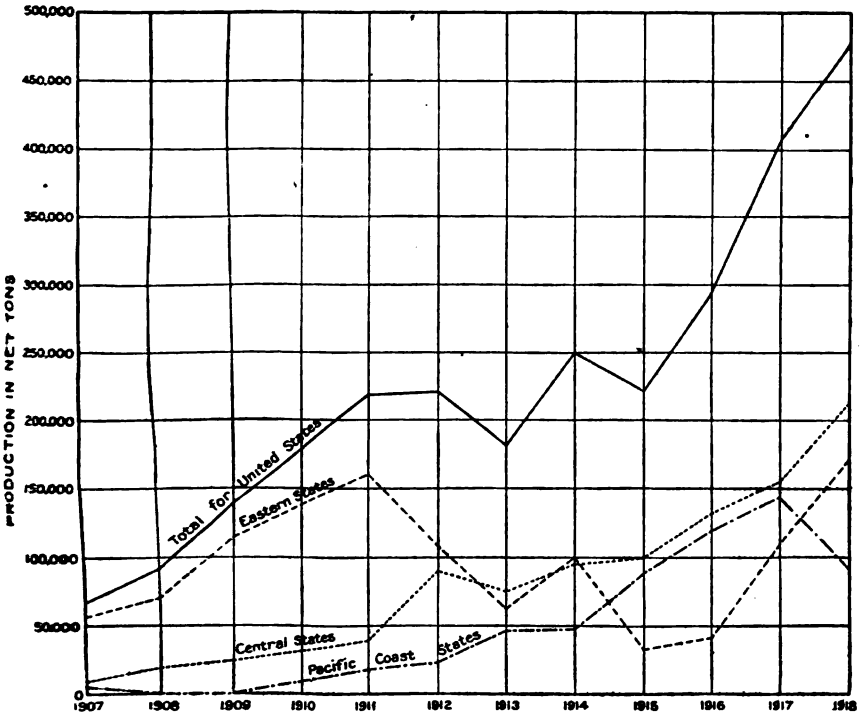

FIGURE 1.—Production of fuel briquets, 1907-1918, in the Eastern, Central, and Pacific Coast States and in the United States.

and represented the third successive year of material progress in the industry, being more than double the output in 1915. The progress of the industry in the 12 years 1907 to 1918, inclusive, is shown graphically in the accompanying diagram.

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Fuel briquets produced in the United States in 1917 and 1918.

	1917			1918		
	Number of operating plants.	Quantity (net tons).	Value.	Number of operating plants.	Quantity (net tons).	Value.
Eastern States:						
New Jersey [a]				2		
Pennsylvania	4			3		
Virginia	1			1		
	5	108,632	$344,068	6	172,266	$728,017
Central States:						
Colorado [b]	1					
Missouri	1			1		
North Dakota [b]	1					
Wisconsin	2			2		
	5	155,140	1,056,051	3	213,030	1,741,769
Pacific Coast States:						
California	1			1		
Oregon	1			1		
Washington	1			1		
	3	143,064	833,769	3	91,939	743,007
	13	406,856	2,233,888	12	477,235	3,212,793

[a] No production in 1917. [b] No production in 1918.

Fuel briquets produced in the United States in 1907–1909 and 1911–1918, in net tons.

Year.	Quantity.	Value.	Year.	Quantity.	Value.
1907	66,524	$258,426	1914	250,635	$1,154,678
1908	90,358	323,057	1915	221,537	1,035,716
1909	139,661	452,697	1916	295,155	1,445,662
1911	218,443	808,721	1917	406,856	2,233,888
1912	220,064	952,261	1918	477,235	3,212,793
1913	181,859	1,007,327			

Raw fuels used in making briquets in 1917 and 1918, in net tons.

	1917	1918
Anthracite culm and fine sizes	137,659	209,690
Semianthracite, Semibituminous, Bituminous slack	161,269	180,714
Lignite and subbituminous coal, Oil-gas residue	103,408	76,602
	402,336	467,006

In the Eastern States production increased 59 per cent and in the Central States 37 per cent, but in the Pacific Coast States production decreased 36 per cent.

The number of plants in operation in 1918 was one less than in 1917. Three of the plants that were operated in 1917 were idle in 1918—those of the Denver Coal By-products Co. (formerly the American Coal Reduction & By-products Co.) in Colorado, the Johnson Fuel Co. in North Dakota, and the American Briquet Co. in Pennsylvania. Two companies began operations at Trenton, N. J.,

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in 1918—the Fuel Briquet Co. and the Trent Brick Co. The Belgian Coal Briquette Co., of New York City, and the Anthracite Briquet Co., of Sunbury, Pa., expect to begin operations in 1919.

RAW MATERIALS AND BINDERS.

Of the 12 plants in operation in 1918, 6 used anthracite as a raw material, 1 Arkansas semianthracite, 1 semibituminous slack, 1 anthracite culm and bituminous slack, 1 bituminous slack and subbituminous coal, and 2 oil-gas residue. Six plants used coal-tar pitch and asphaltic pitch for binders, 1 used sulphite pitch, 3 used vegetable binders or other special processes in manufacturing, and 2 used no binder.

PLANTS.

Briquetting plants operated in the United States in 1918.

Group.	Name and address of operator.	Location of plant.	Date put in operation.	Raw fuel used.
EASTERN STATES.				
New Jersey	Fuel Briquet Co., 30 East Forty-second Street, New York, N. Y.	Trenton	1918	Anthracite.
Do	Trent Brick Co., Princeton Avenue, Trenton, N. J.	.....do	1918	Do.
Pennsylvania	Gamble Briquette Co., Ninth and Dock Streets, Harrisburg, Pa.	Harrisburg	1916	Do.
Do	Lehigh Coal & Navigation Co., 437 Chestnut Street, Philadelphia, Pa.	Lansford	a1909	Do.
Do	Scranton Anthracite Briquette Co., Dickson City, Pa.	Dickson City	1907	Do.
Virginia	Delparen Anthracite Briquet Co., 1 Broadway, New York, N. Y.	Parrott	1915	Do.
CENTRAL STATES.				
Missouri	Standard Briquette Fuel Co., 319 North Fourth Street, St. Louis, Mo.	Kansas City	1909	Arkansas semi-anthracite.
Wisconsin	Berwind Fuel Co., 122 South Michigan Avenue, Chicago, Ill.	Superior	1912	Semibituminous slack.
Do	Stott Briquet Co., Merchants National Bank Building, St. Paul, Minn.	.....do	1909	Anthracite culm and bituminous slack.
PACIFIC COAST STATES.				
California	Los Angeles Gas & Electric Corporation, 645 South Hill Street, Los Angeles, Calif.	Los Angeles	1905	Carbon (petroleum residue).
Oregon	Portland Gas & Coke Co., 294 Yamhill Street, Portland, Oreg.	Linnton	1913	Do.
Washington	Pacific Coast Coal Co., 714 L. C. Smith Building, Seattle, Wash.	Renton	1914	Bituminous slack and subbituminous coal.

a Plant destroyed by fire in 1909; reconstructed in 1911.

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SAND-LIME BRICK.[1]

By JEFFERSON MIDDLETON.

The sand-lime brick industry in common with other building-material industries experienced a severe setback in 1918 by reason of the general conditions prevailing in that year. The decrease in output compared with 1917 was 89,147,000 brick, or nearly 48 per cent. The value decreased $536,401, or nearly 38 per cent. The principal causes of the decrease were the scarcity and high cost of materials and labor, congestion of transportation, and Government restrictions on the use of fuel and on general building. A further reason for the decrease in output in 1918 was possibly the adverse location of many sand-lime brick plants, which were far away from Government buildings that were under construction. With the resumption of general building, which is imminent, the sand-lime brick industry will no doubt share in the increasing demand for brick and show marked advance in 1919. The production in 1918 was the smallest recorded since 1905, and was 128,945,000 brick, or nearly 57 per cent, less than the output of 1916, the year of maximum production, and $590,144, or 40 per cent, less than the value for that year.

The number of operators (42) reporting marketed product in 1918 continued the decrease of previous years and was the smallest since 1903. The average value of sales per active operator in 1918 was $21,046, compared with $30,220 in 1917 and with $27,813 in 1916.

Eighteen States reported sand-lime brick in 1918, a decrease of one—Kentucky. Only one of these States, Louisiana, showed an increase in output; and three, Indiana, Louisiana, and Pennsylvania, increased in value of output. In 1918, as for many years, Michigan was the leading State in sales of sand-lime brick, reporting 23 per cent of the output and 22 per cent of the value. Minnesota ranked second in output but third in value; Pennsylvania was second in value and third in output; New York was fourth in value and sixth in output; Indiana was fourth in output and fifth in value; and Florida was fifth in output and eighth in value. The first five States rated by production reported about 60 per cent of the output and value in 1918.

The average price per thousand for common brick in 1918 was $8.94, compared with $7.54 in 1917 and $6.43 in 1916. For face brick the average price was $11.35, compared with $9.36 in 1917 and $9.64 in 1916.

[1] The statistical data in this report were prepared by Miss Katrine W. Cottrell, of the United States Geological Survey.

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Sand-lime brick marketed in the United States, 1903–1918.

Year.	Number of operators reporting sales.	Quantity (thousands).	Value.	Year.	Number of operators reporting sales.	Quantity (thousands).	Value.
1903	16	20,860	$155,040	1911	66	142,963	$897,664
1904	57	65,127	463,128	1912	71	178,541	1,200,223
1905	84	135,891	972,064	1913	68	189,659	1,238,325
1906	87	164,472	1,170,005	1914	62	172,629	1,068,512
1907	94	173,119	1,225,769	1915	56	179,643	1,135,104
1908	87	139,181	1,029,699	1916	53	227,344	1,474,073
1909	74	151,809	1,150,580	1917	47	187,546	1,420,330
1910	76	172,507	1,169,153	1918	42	98,399	883,929

Sand-lime brick marketed in the United States in 1917 and 1918.

State.	1917			1918		
	Number of operators reporting sales.	Common brick.[a]		Number of operators reporting sales.	Common brick.[b]	
		Quantity (thousands).	Value.		Quantity (thousands).	Value.
Florida	3	14,397	$95,158	2	(c)	(c)
Indiana	3	9,052	60,201	3	7,903	$62,633
Massachusetts	3	15,351	127,695	3	6,851	55,440
Michigan	11	47,998	370,723	9	22,564	198,633
Minnesota	3	23,672	152,531	3	12,255	90,212
New York	3	15,535	130,626	4	6,776	79,515
Pennsylvania	3	11,042	83,123	2	(c)	(c)
South Dakota	2	(c)	(c)	3	1,249	13,617
Texas	3	7,376	65,102	3	2,560	27,384
Other States[d]	13	43,123	335,171	10	38,241	356,495
	47	187,546	1,420,330	42	98,399	883,929

[a] Common brick, except 3,739,000 face brick, valued at $35,011, made in Florida (1,631,000, valued at $13,889), Georgia, Idaho, Indiana, Louisiana, Massachusetts, Michigan (1,019,000, valued at $8,477), and Wisconsin.

[b] Common brick, except 1,581,000 face brick, valued at $17,950, made in Florida, Idaho, Indiana, Massachusetts, Michigan, and Wisconsin.

[c] Included in "Other States."

[d] Includes 1917: California, District of Columbia, Georgia, Idaho, Kentucky, Louisiana, North Dakota, Ohio, South Dakota, Washington, and Wisconsin; 1918: California, District of Columbia, Florida, Georgia, Idaho, Louisiana, North Dakota, Ohio, Pennsylvania, Washington, and Wisconsin.

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GEMS AND PRECIOUS STONES.

By WALDEMAR T. SCHALLER.[1]

PRODUCTION.

The production of gems and precious stones in the United States in 1918 was smaller than in any previous year since 1881, except in 1896. The value of the output in 1918 was only $106,523. The enlistment of many gem miners in the military service, the general scarcity of labor, and the poor market all had their effect in reducing the quantity and value of the precious stones produced.

Value of precious stones produced in the United States, 1913–1918.

	1913	1914	1915	1916	1917	1918
Beryl	$1,615	$2,395	$1,675	$2,031	$2,178	$1,906
Copper ore gems	2,350	1,280	1,120	1,713	2,357	2,299
Corundum	238,835	61,032	88,214	99,180	54,204	42,414
Diamond	6,315	765	608	2 680	4,175	1,910
Feldspar	1,285	449	368	305	(a)	(a)
Garnet	4,285	1,760	4,523	1,542	624	1,277
Hematite	.....	.....	126	(a)	(a)	138
Jade	.....	300	.....	.....	.....	.....
Opal	15,130	1,114	1,850	1,838	805	6,304
Peridot	375	100	(a)	455	(a)	1,018
Pyrite	50	.....	1,042	2,075	(a)	(a)
Quartz	16,861	18,838	35,724	25,707	28,273	15,211
Rhodonite	165	1,060	85	(a)	(a)	515
Smithsonite	50	50	(a)	.....	(a)	.....
Spodumene	6,520	4,000	(a)	(a)	(a)	281
Thomsonite	.....	21	(a)	47	(a)	(a)
Topaz	736	1,280	862	1,005	230	907
Tourmaline	7,680	7,980	10,980	50,807	12,452	6,206
Turquoise	8,075	13,370	11,601	21,811	14,171	20,667
Variscite	6,105	5,055	3,867	3,140	2,350	753
Vesuvianite	152	1,425	1,535	(a)	2,765	320
Miscellaneous gems	2,920	2,287	[b] 6,172	[c] 3,457	[d] 5,928	[e] 4,397
	319,454	124,651	170,431	217,793	131,012	106,523

[a] Small production included under "miscellaneous gems."

[b] Includes apatite, calamine, chlorastrolite, crocidolite, datolite, fossil coral, Iceland spar, kyanite, lapis lazuli, obsidian, peridot, phenacite, rutile, smithsonite, spodumene (kunzite), staurolite, thomsonite, titanite, and zircon.

[c] Includes chlorastrolite, datolite, epidote, fossil coral, hematite, kyanite, lazulite, rhodonite, rutile, sepiolite, serpentine, spodumene, staurolite, and vesuvianite.

[d] Includes andalusite, chlorastrolite, datolite, epidote, feldspar, fossil coral, hematite, Iceland spar, lapis lazuli, obsidian, peridot, phenacite, pyrite, rhodonite, rutile, sepiolite, smithsonite, spodumene, staurolite, thomsonite, willemite, and zoisite.

[e] Includes andalusite, calamine, chlorastrolite, datolite, epidote, feldspar, fluorite, Iceland spar, lapis lazuli, mariposite, meerschaum, obsidian, phenacite, pyrite, satin spar (gypsum), staurolite, thomsonite, willemite, and zoisite.

The value given in the table largely represents the value of the rough material; the value of the cut and polished gems is several times greater. The completeness and accuracy of the statistics of

[1] The tables giving statistics of the value of the gems and precious stones produced in the United States in 1918 were compiled by Miss Blanche H. Stoddard, of the United States Geological Survey.

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production depend on the assistance rendered by the gem miners and dealers, and their help is greatly appreciated. The Geological Survey carries on a large correspondence concerning precious stones, and the information furnished by the individual producers enables the Survey to put intending purchasers of rough material directly in touch with them.

Corundum, quartz, tourmaline, and turquoise constituted 79 per cent of the total value of the precious stones produced in 1918.

Value of principal precious stones produced in the United States, 1911–1918.

Year.	Corundum.[a]		Quartz.[b]		Tourmaline.		Turquoise.		Total value.	Percentage of total shown by corundum, quartz, tourmaline, and turquoise.
	Value.	Percentage of total.	Value.	Percentage of total.	Value.	Percentage of total.	Value.	Percentage of total.		
1911	$215,523	62	$30,227	9	$16,445	5	$44,751	13	$343,692	89
1912	197,765	62	21,779	7	28,200	9	10,140	3	319,722	81
1913	238,835	75	16,861	5	7,630	2	8,075	3	319,454	85
1914	61,032	49	18,838	15	7,980	6	13,370	11	124,651	81
1915	88,214	52	35,724	21	10,969	6	11,691	7	170,431	86
1916	99,180	46	25,707	12	50,807	23	21,811	10	217,793	91
1917	54,204	41	28,273	22	12,452	10	14,171	11	131,012	84
1918	42,414	40	15,211	14	6,206	6	20,667	19	106,523	79
Average for 1911–1918		58		11		8		8		85

[a] Includes ruby and sapphire.
[b] Includes all varieties of quartz, such as amethyst, rock crystal, chalcedony, agate, jasper, etc.

Reports of actual production were received from 57 persons and companies. A few of these persons are either lapidaries or collectors and not regular producers of precious stones. Thirty-eight distinct mineral species were mined; including all varieties as reported, a total of 75 named precious stones were produced. These came from 27 States (including Hawaii), 8 of which had a production valued at more than $1.000 each.

Value of precious stones produced in 1918, by States.

Montana	$47,753
Nevada	21,674
California	9,572
Arizona	9,206
Maine	7,132
Colorado	3,430
Arkansas and New Mexico	3,089
Other States [1]	4,667
	106,523

Montana continued to lead all the other States in the value of precious stones produced in 1918. The output consisted chiefly of corundum of the variety sapphire, which represented almost half of the total value of all precious stones produced in the United States in 1918. Other gem minerals produced in Montana were agate

[1] Florida, Hawaii, Idaho, Michigan, Minnesota, Nebraska, New Hampshire, New Jersey, New York, North Carolina, North Dakota, Oregon, Pennsylvania, South Dakota, Texas, Utah, Virginia, Washington, and Wyoming. Production of each State less than $1,000.

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(chiefly moss agate), Iceland spar, garnet, and topaz; the last two amounted to only a few dollars in value.

Nevada ranked second in the output of precious stones, showing a greater value than for any other year since 1911. The most valuable gem mineral produced in Nevada was turquoise, followed by opal and variscite.

California was third in rank but had an unusually small output. The gem minerals mined were various forms of quartz (such as jasper, chalcedony, bloodstone, and chrysoprase), beryl, diamond, epidote, lapis lazuli, obsidian, rhodonite, spodumene, topaz, tourmaline, and vesuvianite. A three-quarter carat diamond was found in Cherokee Flat, Butte County, Calif.

Arizona had a production whose value was only a few hundred dollars less than that of California. The gem minerals produced include the copper-ore gems (azurite, malachite, azurmalachite, and chrysocolla), garnet, obsidian, peridot, opal, agate, jasper, and turquoise.

Maine produced beryl, garnet, amethyst and rock crystal, topaz, and tourmaline.

Colorado produced calamine, amazonstone, fluorite, garnet, hematite, opal, satin spar, phenacite, pyrite, various forms of quartz, topaz, and turquoise.

From Arkansas several hundred carats of diamonds were reported, including a canary-colored octahedron weighing 17.85 carats, a clear flat stone of 11 carats, and several smaller stones weighing several carats each.

In New York City garnet of gem quality was collected by Gilman S. Stanton and James G. Manchester in November, 1918, on Riverside Drive, north of West One hundred and sixty-fifth Street. The cut stones are deeper red than the spessartites found on the same ridge about half a mile farther north.[1] A number of stones have been cut, the largest about three-fourths of a carat in size. Chemical tests show that the garnet contains both iron and manganese, being intermediate in composition between almandite and spessartite.

In Hawaii an area of decomposed lava contains numerous yellowish-green crystals of peridot, which were cut in Honolulu into gems weighing as much as a carat and a half each. The crystals were separated from the sandy decomposed lava by sifting, and many also were brought to notice by the action of rain. Four workmen are said to have obtained 30,000 fragments of peridot in five days' work.

FOREIGN OCCURRENCES.

DIAMONDS IN SOUTH AFRICA.

A large blue-white diamond, weighing 388¼ carats[2] in its rough state, has been reported as found at the Jagersfontein mine, Orange River Colony, South Africa. Although small in comparison to the Cullinan diamond (3,052 carats), it will rank as one of the world's largest diamonds. The Jagersfontein mine in 1893 yielded the Excelsior, a diamond weighing 969½ carats in the rough. For comparison it may be stated that the largest cut stone obtained from the Cullinan weighs 516½ carats.

[1] U. S. Geol. Survey Mineral Resources, 1916, pt. 2, p. 894, 1918.
[2] Presumably "English carats." The weights of the older stones are given in English carats. One English carat weighs 205.304 milligrams.

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A large diamond, free from flaws, was picked up by a native in September, 1917, on the Dutoitspan mine dump at Kimberley. The stone weighs 442¼ carats and is a record stone for this mine. Although slightly smaller than the large diamond of 503¼ carats discovered in the De Beers mine in 1896, the stone picked up recently is the most valuable diamond ever found at Kimberley in the mines of the De Beers Consolidated Mines Co.

It is said that there are not enough new diamonds in the world to supply the unprecedented increased demand from nearly all countries in the last few months. The shortage is due to the four and a half years of war, during which mining operations were completely suspended for a period of a year and a half and were resumed on a greatly reduced scale. The diamond dealers in the United States have in the meantime been replenishing their stocks from the accumulated surplus that had been mined prior to the war.

The competition which formerly existed in the world's diamond market has completely disappeared because of Germany's loss of German Southwest Africa, the output of which was large enough to be a factor in the market. The former German possession is now held by the British. With this competition eliminated, it is pointed out by leading American diamond dealers, 95 per cent of the world's production of diamonds will be under control of the De Beers Consolidated Mines Co. and its selling agents.

Holland and Belgium did most of the diamond cutting before the war, France and England cutting smaller quantities. The industry has been practically suspended in Belgium, has increased in Holland, and remains about the same in France and England.

It is estimated that about half of the mined diamonds of the world are owned in the United States and that their value exceeds a billion dollars.

AGATE AND AMETHYST IN URUGUAY.

Agates and amethysts are found in the Departments of Tacuarembo, Paysandu, Salto, and Artigas, in the northwestern part of Uruguay. Agate is abundant in many curious and beautiful forms and in a great variety of colors. Amethyst occurs in geodes, which are collected in the fields at a nominal cost, taken on mule-back or in carts to the nearest railway station, shipped from there in barrels to Salto, and thence by river boat to Montevideo. The finest amethysts, of a deep violet color, equal to the best European material, come from Artigas, near the Brazilian border.

Little exact information as to the output of amethyst is available. In 1909, which was a normal year, exports are estimated to have been between 13,000 and 15,000 pounds. Practically the entire output of rough amethyst and agate was formerly exported to Germany to be cut at Idar and Oberstein. The value of rough amethyst varies greatly according to purity and color, ranging from 10 centimos (10.34 cents) to 12 pesos ($12.41) per kilo (2.2 pounds), and exceptionally as high as 40 pesos ($41.36) per kilo has been paid. The output since 1914 has been very small and irregular, owing in part to the depletion of the supply of stones of good quality.

The Morgan Gem Hall of the American Museum of Natural History, New York City, has recently acquired a beautiful statuette, 8 inches high, of a woman dancing, carved out of an unusually perfect block of translucent natural sapphirine (blue quartz) from Uruguay.

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IMPORTS AND EXPORTS.

The precious stones (excluding pearls) imported into the United States in 1918, as reported by the Bureau of Foreign and Domestic Commerce, Department of Commerce, were valued at $22,666,839. Pearls are omitted from the total value, as they are lustrous calcareous concretions with animal membrane between successive layers and are not a mineral but an animal product, being deposited in the shells of various mollusks. As pearls owe their beauty and value to the organic part of their composition, they do not come within the scope of this report. They are, however, among the most desired of gems, and their value is therefore given in a separate column in the table of imports.

Including pearls, the value of imported gems in 1918 was the lowest for the last 10 years except that in 1914.

Diamonds and other precious stones imported and entered for consumption in the United States, 1909–1918.

Year.	Diamonds.				Other stones not set.	Total, excluding pearls.	Pearls.
	Glazier's.	Dust and bort.	Rough or uncut.	Cut but not set.			
1909	$758,865	$50,265	$8,033,379	$27,361,799	$4,033,201	$40,237,509	$24,848
1910	213,701	54,701	8,991,890	25,593,641	4,237,232	39,091,165	1,626,083
1911	199,930	110,434	9,654,219	25,676,302	3,820,703	39,461,588	1,284,376
1912	452,810	94,396	9,414,514	22,865,686	3,433,163	36,260,569	5,130,376
1913	471,712	100,704	12,268,543	24,812,604	2,805,963	40,459,526	5,002,624
1914	579,332	77,408	2,851,933	11,976,871	1,649,875	17,135,419	2,090,018
1915	366,793	75,944	7,020,646	13,177,919	1,078,391	21,719,693	4,513,909
1916	836,018	67,290	11,441,328	24,282,140	2,303,351	38,930,127	11,336,971
1917	1,098,102	349,746	13,092,855	18,421,838	1,883,810	34,846,351	4,947,509
1918	718,397	475,870	12,636,024	7,734,150	1,102,398	22,666,839	765,929

Value of diamonds imported into the United States in the fiscal years 1913 to 1918, by countries.

Uncut.

Year.	United Kingdom.	Belgium.	Holland.	British South Africa.	Brazil.	Germany.	All others.	Total.
1913	$8,635,000	$2,130,000	$963,000	$5,000	$70,000	$68,000	$469,000	$12,340,000
1914	6,132,000	974,000	504,000	.....	74,000	1,000	422,000	8,107,000
1915	2,879,000	5,000	331,000	59,000	148,000	1,000	191,000	3,614,000
1916	10,718,000	.....	210,000	315,000	685,000	.....	258,000	12,186,000
1917	10,919,000	.....	85,000	445,000	1,000,000	.....	207,000	12,656,000
1918	12,285,000	.....	130,000	276,000	1,194,000	.....	193,000	14,078,000

Cut but not set.

Year.	Holland.	Belgium.	England.	France.	Brazil.	Germany.	All others.	Total.
1913	$10,853,000	$11,997,000	$1,583,000	$2,483,000	.....	$254,000	$43,000	$27,213,000
1914	6,998,000	8,555,000	540,000	1,506,000	$4,090	87,000	105,090	17,795,000
1915	5,552,000	972,000	1,169,000	518,000	.....	16,000	225,000	8,452,000
1916	16,422,000	68,000	1,817,000	1,679,000	171,000	28,000	382,000	20,567,000
1917	17,856,000	.....	2,153,000	1,406,000	13,000	47,000	381,000	21,856,000
1918	11,306,000	.....	1,887,000	712,000	6,000	.....	39,000	13,930,000

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Foreign precious stones reexported, 1913–1918.

Year.	Diamonds.			Other precious stones.		Total, excluding pearls.	Pearls and parts of, not strung or set.
	Uncut.	Cut but not set.	Bort.	Uncut.	Cut but not set.		
1913	$1,870	$57,117	(a)	$1,707	$7,239	$67,933	$24,787
1914	14,809	20,350	(a)	2,573	53,086	90,818	1,066
1915	97,764	5,119	$2,470	661	10,554	116,568	116,809
1916	6,979	9,342	4	9,023	48,352	73,700	894,115
1917	7,757	400	14,962	1,512	16,842	41,473	20,353
1918	[b] 100	.....	56	.....	57	213	42,908

[a] Not shown for these years. [b] Includes some bort.

SOME INDUSTRIAL USES OF PRECIOUS STONES.

In the following paragraphs are given some industrial uses of minerals of gem quality. In addition to ornamentation, all gem minerals are of value as specimens for collections, for use in standardization (for example, fluorite and quartz as standards of densities and of refractive indices), and as sources of material for investigation, both industrial and scientific. These uses are therefore not always repeated under the different mineral names. Ornamentation itself covers a variety of utilization, such as for jewelry, knife handles, paper weights, and pipes (meerschaum).

Agate. Mechanical bearings and supports, scale bearings, balls for water meters.
Azurite. Ore of copper; pigment for paint.
Azurmalachite. Ore of copper.
Calcite. See Iceland spar.
Chromite. Ore of chromium.
Chrysocolla. Ore of copper.
Cobaltite. Ore of cobalt.
Corundum. See Sapphire.
Diamond. Cutting, grinding, engraving, boring, and polishing material; supports for bearings and pivots; dies for wire drawing; tips for phonograph needles.
Epidote. For coloring artificial slate and roofing material.
Fluorite. See Optical fluorite.
Franklinite. Ore of manganese and zinc.
Garnet. Abrasive; for watch jewels or jeweled bearings; as tared weights.
Garnierite. Ore of nickel.
Gypsum. Used in manufacture of artificial pearls—the so-called "Roman pearls."
Hematite. Ore of iron.
Iceland spar.—Iceland spar is a variety of calcite, clear and transparent and unusually free from imperfections and impurities. Transparent crystals or cleavage pieces of calcite of any appreciable size are very rare, and as Iceland has furnished almost all of such material used, the name Iceland spar has been given it.

Elongated cleavage rhombohedrous of Iceland spar are used in the manufacture of nicol prisms, which are an essential part of optical instruments requiring plane polarized light, as, for example, certain microscopes, dichroscopes, and saccharimeters. The material, on account of its simple chemical composition and purity, finds application in chemical standardization. Iceland spar is also used in the manufacture of some kinds of glass, and some of it is sold as mineral specimens.

Pieces of Iceland spar, either in single untwinned crystals or parts of such crystals, or in homogeneous untwinned cleavage rhombohedra, which are large enough to yield a rectangular prism at least 1 inch long and half an inch thick each way and which possess the properties described below, are suitable for optical purposes. The colorless material must be so clear and transparent that it is limpid and pellucid. It must not be partly opaque on account of numerous cracks or fractures, must not show any internal, iridescent, or rainbow colors due to

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incipient cracks along fracture lines, nor any cleavage, nor twinning planes. Neither can there be any capillary or larger tubelike cavities, nor cavities or bubbles of any shape, nor inclusions, as isolated particles, veins, or clouds, composed of minute crystals of some other mineral or of any kind of foreign substance. The spar should not be discolored or stained by the presence of any clay, iron oxide, or other material. It should be noted that many of the inclusions and imperfections of Iceland spar are not always scattered irregularly through the mineral or even segregated in distinct masses, but frequently lie in a distinct but very thin plane which can hardly be seen if looked at on edge. In examining a piece of Iceland spar for defects the piece should therefore be turned in all directions while held to the light.

The material suitable for optical uses naturally brings the highest prices, as it has to be at least of the dimensions already given. Specimen material is generally of a larger size. The material used for standardization, chiefly chemical, need be of no special size, and the smaller pieces are as usable as the larger ones.

The optical variety of Iceland spar produced in the United States, sold, per pound, for $3 to $4 in 1914, about $8 in 1915, and as high as $20 in July, 1918. The specimen variety sells for considerably less, and material for standardization sells for from $1 to $2 a pound.

The following firms are buyers of Iceland spar suitable for optical use: Bausch & Lomb Optical Co., Purchasing Department, Rochester, N. Y.; Central Scientific Co., 460 Ohio Street east, Chicago, Ill.; Gilbert S. Dey, Superintendent Optical Department, Eastman Kodak Co., Rochester, N. Y.

The market for specimen spar is irregular, as the demand is usually very light. The best market will probably be found with some of the larger mineral dealers.

Standardization material may be sold to large dealers in general chemicals as well as to mineral dealers.

Although calcite is, next to quartz, the commonest mineral, the only locality outside of Iceland known to produce the variety Iceland spar in commercial quantity is in Montana, about 9 miles from Gray Cliff, Sweet Grass County, on the main line of the Northern Pacific Railway. The spar occurs in a nearly vertical fissure vein from 3 to 8 feet thick, which strikes northwest, traversing a gneissic rock for several miles.

Brief mention of the Montana occurrence of Iceland spar is made in the reports on the production of gems and precious stones in Mineral Resources for 1913 (p. 704) and 1914 (p. 335). C. L. Parsons, of the Bureau of Mines, has also described the occurrence and material in Science, vol. 47, No. 1221, pp. 508–509, May 24, 1918.

Jasper. See Agate.

Malachite. Ore of copper, pigment for paint.

Mariposite. Pigment for paint.

Meerschaum. Pipe bowls; cigar and cigarette holders.

Optical fluorite. Fluorite, commonly called fluorspar, is a common mineral but is very seldom found in pieces clear enough and large enough to be of special use in the manufacture of certain optical lenses and prisms. Fluorite of the requisite qualities, as described below, suitable for such use is known as "optical fluorite." Any deposit of fluorite may yield a small quantity of such material, but at present about the only localities known to produce it are southern Illinois; Meiringen, Switzerland; and Obira, Bungo, Japan. Optical fluorite is cut into lenses and placed between glass lenses. It forms the apochromatic objective for microscopes and similar optical instruments, the fluorite lens correcting the spherical and chromatic errors of the glass lens systems. This result is due to the low refractive power, weak color dispersion, and single refraction of fluorite. These apochromatic lenses represent the finest type of microscope objectives made. The use of such a fluorite lens greatly increases the value of a microscope and if optical fluorite were more abundant many more microscope objectives would be equipped with such lenses.

Optical fluorite is also used in the lenses of certain telescopes, in making prisms for spectrographs in ultra-violet work, and in other optical apparatus where transparency in the ultra-violet and infrared parts of the spectrum is necessary.

Optical fluorite must yield or contain pieces at least one-fourth of an inch in diameter, which must be clear and colorless and free from all defects. Defects consist of internal cracks or cleavage planes, bubbles, or inclusions of dirt or mineral matter. The presence of faintly developed or incipient cleavage planes or fracture surfaces usually may be determined, if not readily visible, by moistening the specimen with kerosene. The material must not show any anomalous double refraction. Absolutely water-clear material is of the highest value, but very faint tints of green, yellow, or purple do not render the material useless.

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Fluorite suitable for optical use is valued at from $1 to $10 a pound, according to the size of the piece suitable for cutting as well as to its quality. The present yearly requirement is not large—perhaps several hundred pounds—but under proper conditions and with a dependable steady supply this requirement may be increased.

Possible buyers of optical fluorite are: Bausch & Lomb Optical Co., Rochester, N.Y.; Spencer Lens Co., Buffalo, N. Y.; Ward's Natural Science Establishment, Rochester, N. Y.; United States Bureau of Standards, Washington, D. C.

Suitable material has been obtained from several of the fluorite mines in Hardin County, Ill., and may also occur in the extension of this fluorite belt in western Kentucky. Although fluorite is found in many other States, practically none of them is known to contain any "optical fluorite."

Among publications dealing with optical fluorite are the following:

Pogue, J. E., Optical fluorite in southern Illinois: Separate from Bull. 38, Illinois State Geol. Survey, Urbana, Ill., 1918.

Burchard, E. F., Fluorspar and cryolite in 1917: U. S. Geol. Survey, Mineral Resources, 1918, pt. 2, pp. 301-302, 1918.

U. S. Bureau of Standards, Washington, D. C.: Circular letter dated May 8, 1918.

Quartz. See Rock crystal.

Rock crystal.—The perfectly clear and colorless variety of quartz is called rock crystal. It furnishes the material for certain special glasses and fused silica ware; and it is used in wedges for microscopic work, as spectographic prisms for special researches, and as mechanical bearings. A use in connection with certain sounding boxes has recently been developed.

Sepiolite. See Meerschaum.

Sapphire. The variety of gem corundum used for other purposes than jewelry is called sapphire, irrespective of its color. It is used for mechanical bearings and pivot supports, especially in watches and phonograph needles (mostly artificial sapphire).

Topaz. Abrasive.

Tourmaline. In the tourmaline tongs or in polarizing forceps, a very simple form of polariscope.

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PRICES OF COAL AND COKE, 1913–1918.

By C. E. LESHER.

PREFATORY NOTE.

The following paper, which deals with the prices of domestic coal and coke from 1913 to 1918, inclusive, is one of 50 similar studies of war-time prices in different industries prepared by or at the request of the War Industries Board. The aim of these studies is both to make the price quotations gathered by various Government agencies available to men concerned with problems of business readjustment and also to provide a permanent record of the great revolution in prices that accompanied the World War.

This report is one of the products of the joint efforts of the United States Fuel Administration and the United States Geological Survey, which during the war combined their statistical work on coal and coke. It is published as a chapter in the history of the Fuel Administration and as a part of the annual report on the mineral resources of the United States by the Geological Survey for 1918; it is also combined with reports on other commodities in the history of prices published by the War Industries Board.

INTRODUCTION.

In order to throw as much light as possible upon the course of fluctuations in the prices of domestic coal and coke from 1913 to 1918, inclusive, a brief account of conditions prevailing in the coal industry during the period mentioned is given below, together with data regarding production and Government control and a discussion of the factors that exercised special influence upon the markets.

The price charts are drawn on a uniform scale.[1] As the inquiry centers about the effect of the war, the charts are made to show the movement of prices away from the pre-war level. This effect is produced by treating the average actual prices in the 12 months preceding the outbreak of war (July, 1913, to June, 1914, inclusive) as equal to 100 and throwing the actual prices in each month from January, 1913, to December, 1918, into the form of relative prices on that scale. For example, if the selling price of coal averaged $2 a ton in the 12 months before the war and if it fell to $1.80 in October, 1914, the relative price in that month would be 90; if the price rose to $4.60 in July, 1918, the relative price would be 230. On this plan, all the price charts are strictly comparable one with another.

For those who wish to know not merely the fluctuations of particular coals but also the general trend of prices in the bituminous and anthracite industries as a whole, "index numbers" are provided. As index numbers, simple averages of the prices of different coals would obviously have little value. Therefore, in making index numbers the price of each coal is "weighted" by multiplying the monthly

[1] The price charts in this report are uniform in scale with those in the reports on other commodities published by the War Industries Board.

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prices from 1913 to 1918 by the quantity of that coal produced in 1917, which was selected as the weighting year both because the tables are intended to reflect war-time conditions and because when the bulletins were being written data for 1918 were unobtainable for many commodities other than coal.

An enumeration of the successive steps in making these index numbers will show how simple the figures are. First, for every coal included in the computation the quantity produced in the United States in 1917 was determined; this quantity represented the "weight." Second, the price of the coal in each month in the six-year period covered was multiplied by the "weight." Third, the products of the different coal prices by their respective "weights" were added up separately for each month. Finally, the monthly aggregates were turned into relatives on the pre-war base—that is, the average aggregates of July, 1913, to June, 1914, were made equal to 100, and all the monthly aggregates were computed to that scale.

Each grade of bituminous coal and each size of anthracite for which price charts are given in this report has been considered as a separate commodity. The prices of the several grades of bituminous coal have been combined into an index for bituminous coal as a whole, the result as shown including also all other bituminous coal and lignite produced in the United States, for which separate price quotations are not given. Likewise, the prices of anthracite have been combined to give one index for the industry as a whole.

It will be seen that the index numbers made on this plan for an industry are strictly comparable with the relative prices for particular commodities shown in the charts. By using these indexes readers can get a clear idea of average price fluctuations in a given branch of business and can compare fluctuations in one industry with those in others.[1]

The time allowed for the completion of this bulletin (two months) was not sufficient to permit as complete a study as was desired by the writer and as the subject deserves. But data regarding war prices appearing a full year after the armistice was signed would have possessed little practical value, however perfect they were as a historical record. The shortcomings of the bulletins as they stand are due largely to the effort to get them published in time to be of practical service to men facing the difficult problems of readjusting prices to a peace basis.

ACKNOWLEDGMENTS.

The writer is indebted to Mr. W. M. J. Lewis, of the Fuel Administration, for the compilation and preparation of all the price data and tables contained in the report. It is due to the energy and care exercised by Mr. Lewis that it has been possible to prepare the report in a little over the two months allotted.

[1] Besides the 50 pamphlets devoted to separate industries, the series published by the War Industries Board to which this bulletin belongs includes group studies of the prices of foods, fuels, clothing, metals, building materials, and chemicals. There is also a set of international comparisons of price fluctuations, a special record of Government control over prices during the war, and finally a general summary of the whole inquiry in which the methods employed are set forth more fully and in which also the leading results from all the bulletins are drawn together for comparison.

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BITUMINOUS COAL.

GENERAL SUMMARY.

Selling price, cost of production, and quantity of output of bituminous coal bear interesting relations to one another. In the normal pre-war period represented in this study by the years 1913 to 1915 and the first half of 1916, the average price at which coal sold at the mines was very nearly parallel to and but slightly above the cost of production. The unmined reserves of bituminous coal are tremendous and widespread and yet within comparatively easy reach of railroads already built. Under the present wasteful methods of mining the cost of opening a mine is not great. Labor and machinery have been plentiful. Marketing has presented to the producer, big or little, no serious problems, for the middleman or jobber has furnished a convenient outlet for the output of mines whose operators had no direct connection with consumers. The railroads, the largest single group of coal consumers, have likewise offered an attractive and easily reached market.

In round numbers 80 per cent of the bituminous coal produced goes to the railroads, public utilities, and manufacturing industries, which, taken together, represent a market very little subject to seasonal change but subject to all the vicissitudes of business conditions—the prosperous and the dull times—that mark the ebb and flow of our industrial life. Of the remaining 20 per cent, 4 per cent represents exports—an item so small and local as to have no bearing on the total—and about 16 per cent is taken by domestic consumers, whose use of coal is of course seasonal.

Bituminous coal is not stored, except by the consumer, but moves direct from mine to user. Exceptions that do not affect the general validity of this statement are found in the stocks held in retail dealers' yards, in the not uncommon practice of holding coal in railroad cars—both small items—and in the use of storage docks at the head of the Great Lakes, where millions of tons for the northwestern trade are piled up during the season of summer navigation for use in the winter when the lakes are frozen over. The ability to get bituminous coal to the consumers, which involves not only the number and size of mines and the number of men but the number of railroads, engines, coal cars, switching yards, and sidetracks, must be ample to meet the maximum demand. And if the capacity of the mines and the railroads must be kept up to meet the periodic and temporary big demand for coal, it is evident that in periods of slack demand a part of this huge plant must lie idle. That this is what happens is shown by the statistics of running time. In 1913 there were employed in the production of bituminous coal 571,882 men, who worked an average of 232 days out of a possible 304 working days in the year; in 1914 583,506 men were employed an average of 195 days; in 1915 557,456 men averaged 203 days; and in 1916 561,102 men averaged 230 days. Idle time in these years, ranging from 72 days, or 24 per cent of the total of 304 days, in 1913 to 109 days, or 36 per cent, in 1914, was largely due to lack of business. Conditions in 1917 and the first nine months of 1918 were quite different from those in preceding years; demand generally exceeded supply and transportation was the principal factor limiting production.

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An obvious result of having more mines than are needed at times is the curtailment of output at periods of slack demand and a lowering of prices in an effort to attract business. Cost of production has not always determined the lowest level of price, for ignorance of cost or desire to maintain the working organizations at the mines have often operated to maintain output beyond demand, at times with serious effect on the credit of the industry. For years much coal has been taken from the ground without adequate returns to the producers. The lure of cheap cost of production from thick beds—as in parts of West Virginia and Illinois—and of high prices in prosperous years and periods of coal shortage has attracted to the business of producing coal many men who, once in, have borne loss year after year in the hope of retrieving their losses later.

These conditions in the bituminous coal industry are significant and should be clearly recognized because they show why, in normal times, the price of bituminous coal is not subject to even moderately wide variations. The low levels are reached when those producers that are willing or able to reduce price have supplied the demand. Need for the commodity and not low price induces the purchase of coal. High levels of price are reached when, under the incentive of big profits, production is speeded up and capacity increased to a point where demand is satisfied.

Another and an important reason for fairly stable prices of coal is found in the fact that labor represents nearly 80 per cent of the total cost of production and that wages are pretty generally maintained through the unions. Coal miners' wages are fixed by agreements running from two to four years.

The general principles governing the prices in normal times thus set forth continued to operate through 1916 and until the middle of 1917, although in the later part of this period conditions were far from normal. A tremendous increase in demand, which began in the last quarter of 1916 and extended through 1918 until the armistice was declared in November, brought forth an increase in production to a point where the limit of railroad capacity was temporarily reached with the demand still unsatisfied. Because the demand could not be fully satisfied, prices in the fall of 1916 and in 1917 rose to almost unheard of figures, until first voluntary control and later Government control was exercised.

MARKETING METHODS.

Before describing the price data it is necessary for a proper understanding of the results presented to outline briefly the way in which coal is marketed and how the statistics of price fluctuations were compiled. Coal, like most other commodities, is sold either by contract or on the open market from day to day. Contracts are generally made (1) for a specified quantity to be delivered over a stated period and at an agreed rate per day, week, or month; (2) for a stated quantity per week or month for an indefinite period; (3) for the requirements of the consumer; or, (4) for the output of the mine. There are, of course, many variations to these four classes. Contracts specifying a definite period of time usually cover a year, and the most common period is from April 1 to March 31, the "coal year." Here again there are variations. Contracts are some-

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times made to run for 5, 10, or even 20 years or more. In some fields and for some classes of business the period is not the standard coal year—for instance, railroad fuel contracts in northern West Virginia have usually been made for the period from July 1 to June 30, and the contract period in some of the Western States is September 1 to August 31. A contract period ending with March is logical because that date marks the end of the winter season, through which consumers desire the assurance of a coal supply afforded by a contract. In March and April stocks of coal left over from the previous year are often cleaned up while bargaining for the next year's supply is going on. In the central competitive field, comprising western Pennsylvania, Ohio, Illinois, and Indiana, the greatest of the unionized coal fields, wage agreements are dated from April 1.

Sales of coal on the open market, commonly called "free" or "spot" sales, represent an important part of the coal business. A substantial portion of the soft coal produced is sold through jobbers or wholesalers who do not physically handle the coal but simply buy and sell it. Producers may contract to sell their entire output or a definite quantity to a jobber or jobbers either for a stated price or for a fixed percentage of the ultimate selling price. So far as the producer is concerned such coal is under contract, but the jobber may sell the coal on the spot market or may in turn contract for its delivery to a consumer. Or the product of one or more mines may all be sold through a sales agency, usually on commission.

Although selling policy varies according to circumstances, producers and jobbers usually endeavor to place a substantial portion of their expected output under contract. The days a mine is idle not only mean no revenue but an increase in average cost of production. Contracts are the best assurance of continuous operation. The entire output of many mines is sold by contract to single consumers, such as railroads, public utilities, or large industrial establishments. The desire to make a contract for coal is strongest on the part of a producer when the market is falling and on the part of a buyer when the market is advancing.

There may be and usually are two prices for the same coal—the price at which the vendor will enter into a contract to deliver coal over a period of time and the price at which he will either sell a certain quantity at the time or accept an open order for delivery at the "market" price until further notice, essentially a spot sale. Spot prices may be higher or lower than contract prices, according to circumstances. They are, as a rule, lower in summer, because of slack demand, and higher in winter. Spot prices are often lowest in April, because in that month demand is lowest and buyers are concerned in negotiating for the lowest possible prices for the ensuing year's contracts.

The combination of all sales, both contract and spot, gives a figure of actual realization which represents the average of all transactions. Prices are the figures at which sales were made, without regard to the quantity sold. Average realization is obtained by dividing the total dollars obtained by the total tons sold and is therefore an average weighted price. Both prices and realization must be considered in a study of the history of prices such as is attempted in this report.

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SOURCE, COMPLETENESS, AND METHOD OF COMPILATION OF PRICE DATA.

Current quotations from January 1, 1913, to September 1, 1917, on the several coals described separately in this report were taken from the weekly market reports of the trade paper, the Coal Age. Prices fixed by the President August 21, 1917, and subsequently modified by the Fuel Administrator, were used beginning with September, 1917. The mean of the high and low weekly quotations from the Coal Age were, where necessary, reduced to a basis of net tons and prices f. o. b. mines by deducting the freight rate in effect at the particular time. The weekly prices were then reduced to monthly prices by taking the simple average. A single quotation was then obtained for each coal for each month by averaging the quotations for prepared sizes, run of mine, and slack or screenings in accordance with the proportion of each size produced in each field in 1917. In this way more than 35,000 quotations were examined and reduced to 1,080 average monthly quotations—12 monthly averages each for six years for 15 bituminous coals. These are the "spot" prices given by years, quarters, and months for each of 15 coals in the tables. It is believed that the quotations from the Coal Age were fairly representative of the spot markets selected and that the method of combining the quotations for various coals at the several markets by sizes to a uniform run-of-mine basis gives a result that is as fair as can be shown within the limits of this report. Much interest would attach to a study of the current prices on different sizes of each coal, but the time available for preparation and the size of this report preclude an attempt to present that side of the subject.

The ideal set of figures would show for each coal, each month, three prices—the spot price, the contract price, and the average realization price, which would be a combination of the first two—all properly weighted in accordance with the quantity of coal delivered. Such figures are not available and would be impossible to obtain. Because so large a portion of the coal is delivered on contract, the spot quotations do not truly represent the price at which all bituminous coal is being marketed. The spot price is subject to greater and more frequent fluctuations than the contract price. A curve showing the average value in dollars and cents obtained from the sale of coal each month would, because of the steadying effect of contract sales, go neither so high nor so low as the curve of spot prices. An attempt has been made to set forth a set of figures showing average realization price, which are given both in tables and in diagrams and are described as "spot prices reduced to average realization base."

The method of arriving at the spot prices reduced to average realization base was as follows: The average realization price per ton for each calendar year was obtained from the reports on coal of the Geological Survey by dividing the total dollars received f. o. b. mines by the total number of tons of each coal. This figure is an average for 12 months and would be represented on the diagram by a straight line, with none of the monthly fluctuations that really took place. Furthermore, these annual averages are for calendar years, whereas the annual break in average realization more nearly corresponds to

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the coal year beginning April 1. These annual average figures of realization were therefore arbitrarily moved forward three months, the figures for the calendar year 1914 being considered to apply to the 12 months beginning April 1, 1914, and ending March 31, 1915. Without regard to quantity of coal produced in any month, the spot prices for each coal year were reduced or raised proportionately, so that their arithmetic mean would equal the average realization price. On the assumption, arbitrarily made, that the average realization price represents the sale price of coal delivered on contract, that the modified spot prices represent the price on current sales, and that three-fourths of the coal was sold on contract and one-fourth on the spot market, a figure for each coal for each month was calculated that is three-fourths average realization price and one-fourth spot price reduced to average realization price.

From September, 1917, to December, 1918, the prices fixed by the Government were considered spot prices, and from April to December, 1918, the same prices were taken for the spot reduced to average realization, the actual realization for 1918 not being available. The figures are given in tables following those of spot prices.

It is believed that these figures represent the true condition of the market for coal more nearly than the spot prices. Whatever the objections to which this method of computation may be subject, it has the advantage of being based on a positive figure, the actual annual average return per ton of coal.

DISTRICTS.

Prices of bituminous coal are presented for 15 districts. The districts selected are those for which comparable quotations were available throughout the entire period of six years. There is no direct relation between these districts and the price districts established by the Fuel Administration. The market quotations carried in the Coal Age are quotations for standard grades of coal from what might be termed trade districts; cost of production was the determining factor in fixing the outlines of the price districts set up by the Fuel Administration. Central Pennsylvania is recognized by the Fuel Administration as one district, but prices are quoted separately for Clearfield coal and for Somerset and Cambria County smokeless coal. The Pocahontas and New River fields of West Virginia were, because of difference in cost of production, divided by the Fuel Administration into two price districts, whereas in normal times the coals from these two fields, of essentially the same quality, competed in the same markets without recognized difference in price. A number of districts treated separately in this report, as those in Illinois, had but one price, which was established by the Fuel Administration.

RELATIVE PRICES.

The diagrams show relative prices, not the actual or average prices described in the preceding paragraphs. This plan of presentation was adopted for this report and others of the series in order to make all price charts strictly comparable. To compare fluctuations in the prices of coal from the Standard field of Illinois, ranging from 84 cents to $2.87 a ton, with those in the prices of Pocahontas coal,

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ranging from $1.09 to $5.34 a ton, the quotations for both are reduced to figures that represent the relation of the high and the low for each to a base price—that is, the average of prices for the 12 months preceding July, 1914. The base price for Standard coal was 91 cents and for Pocahontas $1.30. The base prices are taken as each equivalent to 100. The relative price of Standard coal at 84 cents as the spot price is 92 and for $2.87 as the spot price the relative price is 315. For Pocahontas coal the relative price corresponding to $1.09 spot is 84, and that corresponding to $5.34 is 410. In other words, Standard coal reached a spot price level that was 315 per cent of the average pre-war level, compared to 410 per cent for Pocahontas coal. The lowest level of relative price reached by Standard coal was 92 per cent of the pre-war level, compared to 84 per cent for Pocahontas coal.

In the same way the spot prices reduced to a realization base are converted to relative prices and shown on diagrams.

The price data for the several fields have been consolidated into a total for the United States, which shows the fluctuations for the bituminous industry as a whole through the six-year period. The series of spot prices and of spot prices reduced to realization base were reduced to totals by weighting the prices for each district in accordance with the number of tons produced in 1917—that is, each price was multiplied by the total production in 1917 of the coal represented by that price, the production for corresponding months totaled, and the sum divided by the total production, the result being a weighted average for the United States. These weighted average prices were then reduced to relative prices, as were also those for the several fields. The spot prices given in this report were considered representative of all coal produced east of Mississippi River except in Alabama and Michigan. For these fields and for the districts west of Mississippi River, representing together but 16 per cent of the total production of the country, the annual average realization prices were used in arriving at the averages for the United States in both computations. The error thus introduced is slight, for in those districts for which current quotations were not available, only a small portion of the product is sold on the spot market, and the portion so sold is an insignificant fraction of the total production of the United States.

PRICES.

The diagrams and tables on succeeding pages present the data on prices described above. Certain characteristics that are common to all the curves should first be noted. The most significant features are the abrupt rise in the last half of 1916 from a fairly uniform level in the preceding three and one-half years and the equally abrupt drop in the second half of 1917 after a period of abnormally high prices in the first six months of 1917. The spot market prices, as well as the contract prices, reflect the same tendencies, although not in the same degree. The rise in 1916 followed an increase in demand that the increase in production was unable to satisfy. The drop beginning with July, 1917, was the result of Government control of prices. Discussion of the prices must necessarily be divided at the point where the law of supply and demand was replaced by edict of Government or other arbitrary action.

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In the period prior to July, 1917, the general trend of prices was downward from January, 1913, to July, 1915. In January, 1913, prices in all districts were good and, in the eastern fields, somewhat abnormal. The market in the eastern fields particularly for coal for coastwise business, was better than for more than a year. By the end of January, 1913, the demand declined with unseasonably warm weather, and all districts, except Indiana, recorded a steady drop in the spot price through February and March and, in most of the fields, through April, 1913. The low point for the year was reached in June and July with prices, particularly in the Ohio, West Virginia, and Kentucky fields, rising to a peak in October and November. The

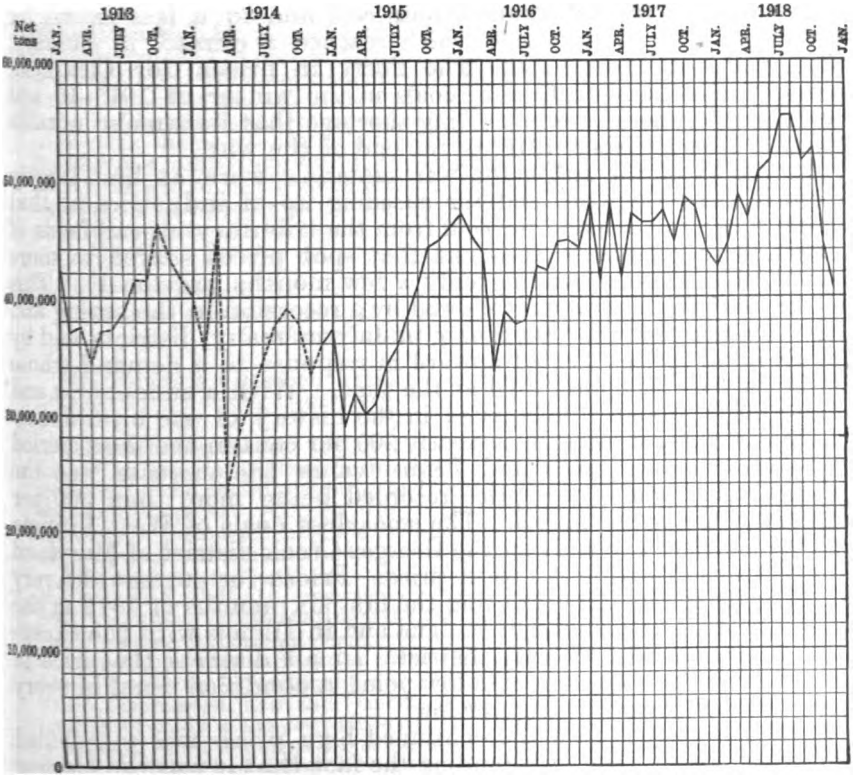

FIGURE 2.—Production of bituminous coal in the United States, by months, 1913–1918.

high point in both price and production for the winter of 1913–14 was reached in October, several months earlier than usual. The price curve for the United States in 1913 (fig. 4, p. 31) follows closely the curve of production (fig. 2). The higher prices in the last half of the year brought forth increased production. It is significant that the peak of production in October, 1913, was nearly as high as in January, 1916, and but little below the maximum reached in 1917, and also that in September and October, 1913, reports of car and labor shortage were currently made. It is evident that, had demand been sustained through the winter of 1913–14, the limitations of car and labor supply would have caused a serious shortage of fuel and a period of high prices

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comparable at least to the winter of 1915–16. The industrial depression of 1914 really began in November, 1913, and caused a falling off in demand that relieved the situation. A large production in March, 1914, was followed in April by the lowest production recorded in the six years under discussion with no marked change in prices. Although demand and production gained through the summer and reached a maximum in September, prices generally continued downward. The only districts that exhibited any marked activity at the end of 1914 were Pittsburgh, Pa., and No. 8, Ohio.

From the low point in April, 1915, production began an increase that was sustained for nine months, or until January, 1916. Spot prices however, did not begin to advance until after the middle of the year, and, except for central Pennsylvania coal and to a less extent for Pittsburgh coal, the advance which reached a climax in January, 1917, was not exceptional. The flurry in prices for Clearfield, Somerset, and Cambria County coals in the winter of 1915–16 was the first evidence of the impending shortage that became so notable a feature from October, 1916, to the end of the war.

The orders of the Allies for war materials were at first largely placed in New England, and the speeding up of industries in that section made the demand for coal from the tributary all-rail fields of eastern Pennsylvania so insistent that spot prices soared to more than double those prevailing only a few months previously. This peak in the price curve was followed by a recession in the spring and early summer of 1916. Beginning in July in many districts and by August in all, prices started upward in response to a demand whose insistence was not appreciated at the time. With a suddenness and to an extent probably unequaled in the history of the bituminous-coal industry, spot prices rose nearly 200 per cent in the short period of six months. In Ohio and Pennsylvania the increase was the greatest, the highest spot price recorded being more than 300 per cent above the pre-war level. The smokeless coals of West Virginia and the high-grade coal from the Georges Creek district of Maryland showed the next highest rise in price. Prices for current delivery remained at the high level during the first six months of 1917 in the eastern fields, but declined in Indiana and in Illinois with the exception of the Franklin County district. In all districts the price in April for free coal represented a low point, a condition usual in every year, whether prices are high or low.

Public discontent with the continued high prices was manifested strongly in June. Notwithstanding the fact that it was the bidding of the consumers against one another that brought about the high prices to an extent equal to if not greater than the setting of the prices by the producer, the producer of coal was held to be responsible for the condition. The Committee on Coal Production of the Council of National Defense, organized in May, 1917, with F. S. Peabody as chairman, called a meeting of representative coal operators from all fields at Washington on June 26 to consider the situation. At the meeting it was made evident that the producers of bituminous coal were willing voluntarily and in concert to reduce prices, but were in fear of condemnation by the Department of Justice for such reduction as combination in restraint of trade. This cause for hesitation was overcome by the action of the Secretary of the

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Interior, the Federal Trade Commission, and the Committee on Coal Production, as representatives of the Government, in standing sponsors for the action of the coal producers. On June 28, 1917, a scale of spot prices was agreed upon, to be effective July 1. A letter from Secretary Lane to Mr. Peabody urging the action by the coal operators, the resolutions passed by the convention, and the statement of agreed prices are given here because they so well express the results of this historic gathering of coal producers.

Letter of Secretary Lane to Mr. F. S. Peabody:

DEPARTMENT OF THE INTERIOR,
OFFICE OF THE SECRETARY,
Washington, June 28, 1917.

DEAR MR. PEABODY: I feel that the present extremely high prices on coal require immediate action by the coal operators and therefore would urge upon you that they should be reduced at once and maximum prices fixed which would apply to sales on and after July 1, 1917, and continue until such time as the investigation which you propose into costs and conditions shall warrant a reduction or increase. These prices should not be used to affect present contracts or apply to export or foreign trade. In other words, the people of the United States should have, as I urged upon the operators the other day, immediate relief and knowledge of their disposition to make a reasonable price irrespective of the possibilities of obtaining higher prices. This would be regarded by the people as meeting the situation promptly and wisely if the prices materially cut those which exist.

Cordially, yours,

FRANKLIN K. LANE.

MR. F. S. PEABODY,
Chairman, Committee on Coal Production,
Council of National Defense.

Resolutions adopted by the convention of coal operators at Washington, D. C., June 28, 1917:

Whereas under the act of Congress approved August 29, 1916, providing that a Council of National Defense be established "for the cooperation of the industries and resources for the national security and welfare, to consist of the Secretary of War, the Secretary of the Navy, the Secretary of the Interior, the Secretary of Agriculture, the Secretary of Commerce, and the Secretary of Labor," authority is given to the council to organize subordinate bodies for its assistance and cooperation, and

Whereas pursuant to this authority the Council of National Defense has appointed Mr. Francis S. Peabody, chairman of and with authority to appoint a Committee on Coal Production, representative of the coal-producing districts of the United States, and

Whereas a great national emergency now exists in the fuel supply of the Nation, and as the coal operators and miners of the United States desire to cooperate as closely as possible with the Government, and as the Department of the Interior, the Federal Trade Commission, and the Committee on Coal Production have given close and intelligent study to the necessities now existing: Therefore be it

Resolved, That it is the sense of this meeting that a committee of seven for each coal-producing State and an additional committee of seven appointed by the representatives of the anthracite industry be appointed by the representatives of each State now attending this convention, to confer with the Secretary of the Interior, the Federal Trade Commission, and the Committee on Coal Production of the Council of National Defense, to the end that production be stimulated and plans be perfected to provide adequate means of distribution, and, further, that these committees report forthwith to the Secretary of the Interior, the Federal Trade Commission, and the Committee on Coal Production of the Council of National Defense costs of and conditions surrounding the production and distribution of coal in each district, and that these committees are authorized, in their discretion, to give assent to such maximum prices for coal f. o. b. cars at mines in the various districts as may be named by the Secretary of the Interior, the Federal Trade Commission, and the Committee on Coal Production of the Council of National Defense.

* * * * * * *

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This convention by resolution heretofore adopted having requested the Secretary of the Interior, the Federal Trade Commission, and the Committee on Coal Production to fix a fair and reasonable price at which the several operators in the several coal districts of the United States shall sell coal, do hereby further authorize said Government representatives, so named in said resolution, to forthwith issue a statement fixing a tentative maximum price which, in their judgment, is fair and reasonable as applied to the several coal districts, at which coal shall be sold from and after the first day of July next and until the accurate costs have been ascertained and a fair and reasonable price based thereon fixed by said Government agencies designated under said resolution: To this end therefore be it

Resolved, That the several States, here represented, do present to the chairman of this this convention a suggestion for use by said agencies in fixing the price which the several interests here represented feel should be the fair and reasonable price to be so tentatively fixed by the said agencies.

The following memorandum of the proceedings was given to the press the night of June 28, 1917:

DEPARTMENT OF THE INTERIOR,
OFFICE OF THE SECRETARY.

As a result of the conference between the mine operators, the Secretary of the Interior, Federal Trade Commissioner Fort, Chairman Peabody, and the Committee on Coal Production of the Council of National Defense, the following reductions were made to go into effect July 1 next in the prices of coal. These prices are maximum prices per ton of 2,000 pounds aboard the cars at mine, pending further investigation. These prices do not affect in any way contracts in existence or sales of coal for foreign or export trade.

The operators tendered to the Government a reduction from these reduced prices of 50 cents per ton for coal that the Government may need.

No action was taken upon anthracite prices because of the fact that these prices had already been acted upon by the Federal Trade Commission.

Twenty-five cents per ton net was fixed as the maximum price for coal jobbers' commission, with only one commission, no matter how many jobbers' hands the coal may pass through.

On account of an inadequate representation of operators west of the Mississippi River, no maximum prices were fixed for coal from those districts. A supplementary statement will be issued within a few days covering prices on coal produced in those districts.

The action taken at this conference brings about the following results:

Present prices on bituminous coal mined in Pennsylvania have ranged from $4.75 to $6. Under the ruling the price is reduced to $3 for mine run and $3.50 for domestic lump, egg, and nut.

The present range of prices in West Virginia is from $4.50 to $6; price reduced to $3 for mine run and $3.50 for domestic lump, egg, and nut.

The range of prices for Ohio coal has been from $4.50 to $5; prices reduced to: No. 8 district, the thick-vein Hocking and Cambridge districts, $3 for mine run and $3.50 for domestic lump, egg, and nut; thin-vein Hocking, Pomeroy, Crooksville, Coshocton, Columbiana County, Tuscarawas County, Amsterdam-Bergholz district, $3.25 for mine run and $3.50 for domestic lump, egg, and nut; the Massillon and Palmyra districts and Jackson County, $3.50 for all grades of coal.

The prevailing prices in Alabama have been from $5.50 to $5.75; prices reduced to: Cahaba and Black Creek, $4; Pratt, Jaeger, and Corona, $3.50; Big Seam, $3 for all grades.

The prevailing prices for coal mined in Maryland have been from $5.75 to $6; reduced prices will be $3 for mine run and $3.50 for domestic lump, egg, and nut.

The prevailing prices on coal mined in Virginia have been $4.50 to $5; reduced price, $3 for mine run and $3.50 for lump, egg, and nut.

The prevailing prices on coal mined in Kentucky have been from $4 to $4.50; reduced price, $3 for mine run and $3.50 for the domestic sizes.

The prevailing prices on coal mined in Illinois and Indiana have been from $3.50 to $4; reduced price, $2.75 for mine run and steam sizes and $3.50 for screened domestic sizes.

The prevailing prices on coal mined in Tennessee have been from $4.50 to $5; reduced price, $3.50 for all sizes.

Whether the reduction in prices thus effected by the voluntary action of the producers would have satisfied the public and met the needs of the situation will never be known, for no sooner were the

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results announced than the Secretary of War, in his capacity as chairman of the Council of National Defense, publicly repudiated the action of the Committee on Coal Production, stating that the prices agreed upon were unwarrantably high.

It is not necessary to pass judgment here on the reasonableness of the Peabody prices. That they were higher than necessary to return the cost of production and a moderately fair profit to the producers has been clearly shown by the subsequent investigation of the committee of engineers of the Fuel Administration. The important point is that the Peabody prices were substantially below those prevailing at the time, that they were from their inception understood to be a temporary stop-gap pending a careful determination of more exact and proper prices, and that they were the first and practically the only prices established by an industry as a whole that represented a reduction for the benefit of the entire public in the history of this war.

The Peabody prices for spot sales were generally observed during July and, except in eastern Pennsylvania and the smokeless-coal districts of West Virginia, in August also until August 21, when the prices were fixed by the President under the authority of the Lever Act. The Peabody prices did not apply to coal sold for export and, as a result, Canadian consumers were able to outbid consumers in the United States. New England and Canada depend upon the fields in central Pennsylvania for their supply by railroad routes. Under these circumstances New England consumers were unable, in July, to obtain satisfactory deliveries of bituminous coal, and in August they induced operators in central Pennsylvania to break away from the Peabody prices. It is thus to be recorded that, although the Peabody prices were claimed to be exorbitant, the only important divergence from those prices resulted from the action of consumers and was an increase.

Government control of the coal industry was assured by the passage by the Congress of the food and fuel control act, generally known as the Lever Act, approved by the President August 10, 1917 (Public—No. 41, 65th Cong.). Acting under the authority of this act the President, on August 21, 1917, announced the following scale of prices for bituminous coal and, on August 23, announced the appointment of H. A. Garfield as United States Fuel Administrator to administer these prices and the provisions of the Lever Act relating to fuel.

THE WHITE HOUSE,
WASHINGTON, *August 21, 1917.*

The following scale of prices is prescribed for bituminous coal at the mine in the several coal-producing districts. It is provisional only. It is subject to reconsideration when the whole method of administering the fuel supplies of the country shall have been satisfactorily organized and put into operation. Subsequent measures will have as their object a fair and equitable control of the distribution of the supply and of the prices not only at the mines but also in the hands of the middlemen and the retailers.

The prices provisionally fixed here are fixed by my authority under the provisions of the recent act of Congress regarding administration of the food supply of the country, which also conferred upon the Executive control of the fuel supply. They are based upon the actual cost of production and are deemed to be not only fair and just but liberal as well. Under them the industry should nowhere lack stimulation.

WOODROW WILSON.

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Prices of bituminous coal fixed by Executive order of August 21, 1917.

	Run of mine.	Prepared sizes.	Slack or screenings.
Pennsylvania	$2.00	$2.25	$1.75
Maryland	2.00	2.25	1.75
West Virginia	2.00	2.25	1.75
West Virginia (New River)	2.15	2.40	1.90
Virginia	2.00	2.25	1.75
Ohio (thick vein)	2.00	2.25	1.75
Ohio (thin vein)	2.35	2.60	2.10
Kentucky	1.95	2.20	1.70
Kentucky (Jellico)	2.40	2.65	2.15
Alabama (big seam)	1.90	2.15	1.65
Alabama (Pratt, Jaeger, and Corona)	2.15	2.40	1.90
Alabama (Cahaba and Black Creek)	2.40	2.65	2.15
Tennessee (eastern)	2.30	2.55	2.05
Tennessee (Jellico)	2.40	2.65	2.15
Indiana	1.95	2.20	1.70
Illinois	1.95	2.20	1.70
Illinois (third vein)	2.40	2.65	2.15
Arkansas	2.65	2.90	2.40
Iowa	2.70	2.95	2.45
Kansas	2.55	2.80	2.30
Missouri	2.70	2.95	2.45
Oklahoma	3.05	3.30	2.80
Texas	2.65	2.90	2.40
Colorado	2.45	2.70	2.20
Montana	2.70	2.95	2.45
New Mexico	2.40	2.65	2.15
Wyoming	2.50	2.75	2.25
Utah	2.60	2.85	2.35
Washington	3.25	3.50	3.00

NOTE.—Prices are f. o. b. mine, basis of 2,000 pounds.

The prices fixed by the President on August 21 were generally about as much below the Peabody prices of July 1 as the Peabody prices were below the spot prices prevailing in June. The opinion was more or less generally expressed by coal producers at the time that for many fields the prices fixed by the President upon the advice of the Federal Trade Commission were too low to stimulate production to supply the needs of the country, although it was granted that a considerable portion of the possible output could be produced at a fair profit under those prices. That this view was correct has been shown by the numerous advances in base price authorized by the Fuel Administrator after full investigation of the cost of production. Some of the more important revisions of the original prices, made as a result of the investigation of the engineers' committee of the Fuel Administration, were those in eastern Kentucky; Kanawha, W. Va.; Georges Creek, Md.; central Pennsylvania; and Hocking, Ohio.

There were two subsequent orders that had a general effect on prices of bituminous coal. On October 27, 1917, the President amended prices generally by adding 45 cents a net ton to the mine price to cover the additional labor cost resulting from the wage advance agreed upon October 6. On May 25, 1918, the Fuel Administrator reduced the price at the mine of all bituminous coal 10 cents a net ton. This reduction was made because of the estimated general leveling and lowering of cost of production accomplished by the elimination of all preferments in car supply, which was brought about by the President acting through the United States Railroad Administration.

Spot prices are only partial evidence of the trend of prices; they are indicative of changing conditions in supply and demand, condi-

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tions which change from day to day and from week to week. Transactions representing sales of coal for periods of a year or more at stable contract prices affect a much larger portion of the output than sales at spot prices. The average prices realized from the sale of all the coal produced do not rise as high or drop as low as the spot prices during the same periods. This is shown in the tables of prices and by the diagrams of relative prices, based on average realization prices and on spot prices. In addition to the relatively lesser variations in average prices realized compared with spot prices, other important differences are the lag in either the rise or the fall of average prices realized compared with spot prices; the usual decline in spot prices in April in periods of rising prices as against increases in average realization prices the same month; and the relatively higher level of the Government prices at the end of 1918 compared with the average pre-war realization prices and with average spot prices in the pre-war period. This was true in all districts for which data are separately presented except two, the Standard and Springfield districts of Illinois. The only significance that attaches to the two districts excepted is that the spot price level in the 12 months preceding the war (the base period) was lower than the average realization price. For one district only of those separately examined, the Carterville and Franklin district of Illinois, the averages of spot prices and of realization prices were identical for the base period.

Comparison of the diagrams of relative prices based on average realization and on spot prices shows also two groups. One group comprises western Kentucky, Illinois, and Indiana, in which the relative increases in the President's prices of August 21, 1917, were greater when compared with the pre-war spot prices than when compared with the pre-war average realization—that is, the first prices fixed, in August, 1917, in those districts were not substantially below the prices prevailing then on all sales. In the other group, mainly the eastern fields, relatively greater decreases were represented in the original prices fixed by the President, and it is to be noted that in this group were allowed subsequently practically the only important revisions upward as the result of investigations of cost of production.

It is perhaps of most importance to note that, although the prices fixed by the Government were substantially below the high levels prevailing in the winter of 1916–17, those finally arrived at in the last half of 1918 were in turn substantially above the average realized on all coal produced in 1916 or 1917, although until the actual amount in dollars realized from the marketing of the 1918 output is known and those figures are substituted for the Government prices in the accompanying tables and diagrams, the actual difference can not be accurately stated. This is true because in this report the prices fixed by the Government have been used from April to December, 1918, both as spot and average realization, whereas the number of contracts extending through this period at prices below the Government maximum may and probably will reduce the average realization price as given. It is not believed, however, that this difference will be great, and the inference to be drawn, from a consideration of all the data presented is that the years 1917 and 1918 represent, for the bituminous coal industry in general, prosperous years.

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It would be interesting to show in this report the relative changes in cost of production for comparison with the changes in prices, but the time allotted to the preparation of the report is so short as to preclude such an undertaking. Complete data on which to base a comparison of the cost of mining of bituminous coal through this period are lacking, but much light would be thrown on the subject by comparison of wages (labor constitutes 75 per cent of the cost of production) and of the cost of some of the principal supplies and machinery used in mining. It is believed that the cost of mining did not advance in proportion to the selling prices; but it is not to be inferred from this that prices in the later years and the Government prices were too high, but rather that in the earlier years of the period under consideration the average margin of profit was very small and that the coal produced was derived largely from the lower-cost operations. To bring forth the greatly needed additional output in the last three years it was essential that many of the higher-cost mines be operated, and to do this a higher average price was necessary.

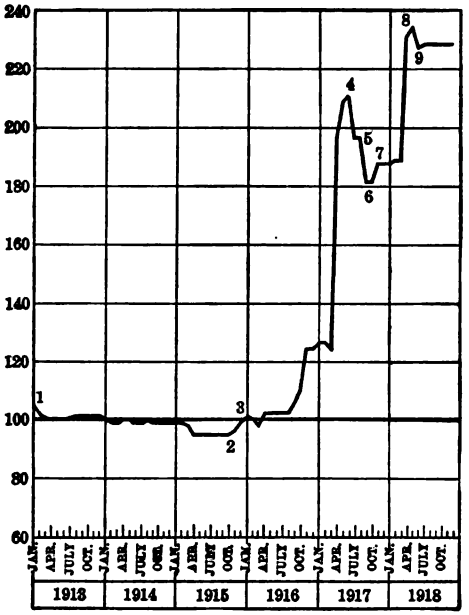

FIGURE 3.—Relative prices realized for all bituminous coal produced in the United States, by months, 1913–1918.

Another feature of the spot prices presented in this report to which no reference has been made thus far concerns the jobber's or middleman's margin. It is assumed that the prices quoted from the Coal Age, on which the tabulation of spot prices has been based, include generally the jobber's margin. For instance, the prices of Pocahontas and New River coal f. o. b. mines are quoted on the Boston market by Boston wholesale houses and must include such wholesaler's margin. The Government prices used in place of quotations in 1917 and 1918 are f. o. b. mines but do not include the jobber's margin or, as finally defined, the purchasing agent's commission.

DIAGRAMS OF RELATIVE PRICES OF BITUMINOUS COAL, 1913–1918.

TOTAL OUTPUT.

The diagrams herewith (figs. 3–35) show the relative prices per ton of 2,000 pounds of all bituminous coal produced in the United States, by months, from 1913 to 1918, inclusive. The numbers preceding the notes in small type refer to corresponding numbers on the diagrams.

Figure 4 shows the relative spot prices in this period compared with the average spot prices in the 12 months preceding the war, July, 1913, to June, 1914. Figure 3 shows the relative range in estimated average

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realization prices (see p. 30) of all sizes and includes both spot and contract transactions. The spot prices are taken from the market quotations of the Coal Age and the average realization prices from annual reports of operators compiled by the United States Geological Survey. Tables of actual prices and of the computed relative prices from which these diagrams were drawn are given on pages 64–87.

Production, 1917, 551,790,000 net tons. Average spot price, pre-war period, $1.27; average realized price, $1.17.

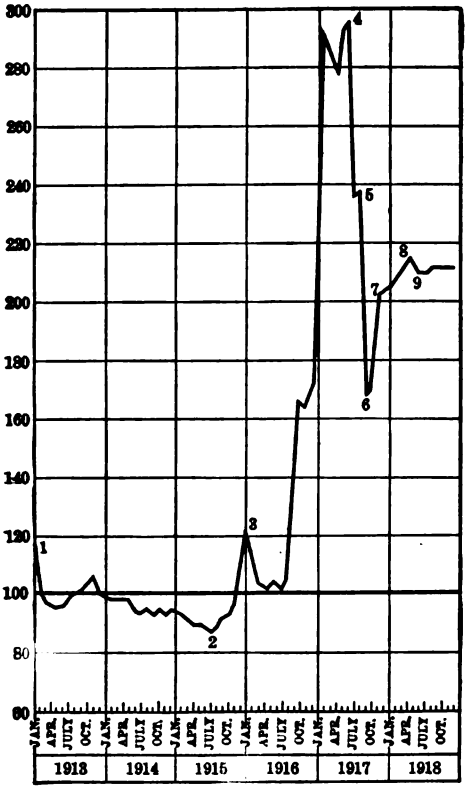

FIGURE 4.—Relative spot prices of all bituminous coal produced in the United States, by months, 1913–1918.

1, 2. The downward trend of the price of bituminous coal in 1913, 1914, and 1915, is shown by both the spot prices and the average prices realized. From a general average spot price of $1.47 in January, 1913 (1), prices declined to $1.14 in July, 1915 (2).

3. The strength of the demand in the winter of 1915–16, particularly manifested in the Eastern States, is indicated by the rise in the general average spot price to $1.54 (3).

4. The highest point reached by the general average spot price was $3.77 in June, 1917 (4).

5. The amount of reduction effected by the Peabody prices is well illustrated by the drop in the curves from (4) to (5).

6. Likewise, the further decrease in the general level of prices brought about by the President's price of August 21, 1917, is shown by the drop in the curves from (5) to (6).

7. The general effect on prices of bituminous coal of the wage advance in November, 1917, is indicated by the rise from (6) to (7).

8. Advances in price in various fields authorized by the Fuel Administrator as the result of investigations of the cost of mining raised the general level gradually to a maximum under Government control in May, 1918 (8).

9. The general reduction in price of 10 cents a ton on all bituminous coal ordered May 25, 1918, is reflected in the curves at (9).

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CARTERVILLE AND FRANKLIN COUNTY DISTRICT, ILL.

Figure 6 shows the relative spot prices in this period compared with the average spot prices in the 12 months preceding the war, July, 1913, to June, 1914. Figure 5 shows the relative range in estimated average realization prices from all sales and includes both spot and contract transactions. The spot prices are taken from the St. Louis market quotations of the Coal Age and the average realization prices from annual reports of operators compiled by the Geological Survey. Tables of actual prices and of the computed relative prices from which these diagrams were drawn are given on pages 64–66.

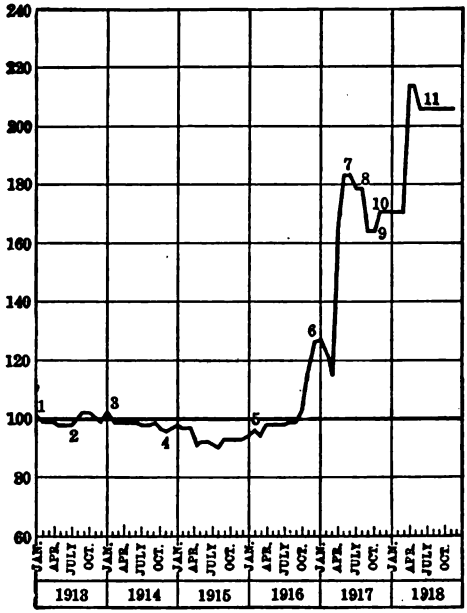

FIGURE 5.—Relative prices realized for bituminous coal produced in the Carterville and Franklin County district, Ill., by months, 1913–1918.

Production, 1917, 28,000,000 net tons. Average spot price, pre-war period, $1.16; average realized price $1.16.

1–5. The average monthly quotations for Carterville and Franklin County coal on the St. Louis market in the period beginning with 1913 to the first half of 1915 ranged from $1.19 in January, 1913 (1), to a low point in June, 1913, of $1.08 (2), and to $1 in November, 1914 (4), and the high price in January, 1914, of $1.28 (3), and in February, 1916, of $1.25 (5).

6. The maximum average monthly quotation for the six-year period covered by this report was for January, 1917, $3.30 (6).

7. Prevailing quotations in May and June, 1917, when the Peabody prices were established, were around $3.19 (7).

8. The prices in July and August, during which the Peabody agreement was in effect, are indicated at (8).

9. The prices established by the President at the end of August, 1917, are indicated at (9).

10. The increase of 45 cents per ton allowed the operators to cover the advance in mine wages authorized in November, 1917, are indicated at (10).

11. The general reduction of 10 cents per ton ordered by the Fuel Administrator on May 25, 1918, is indicated at (11).

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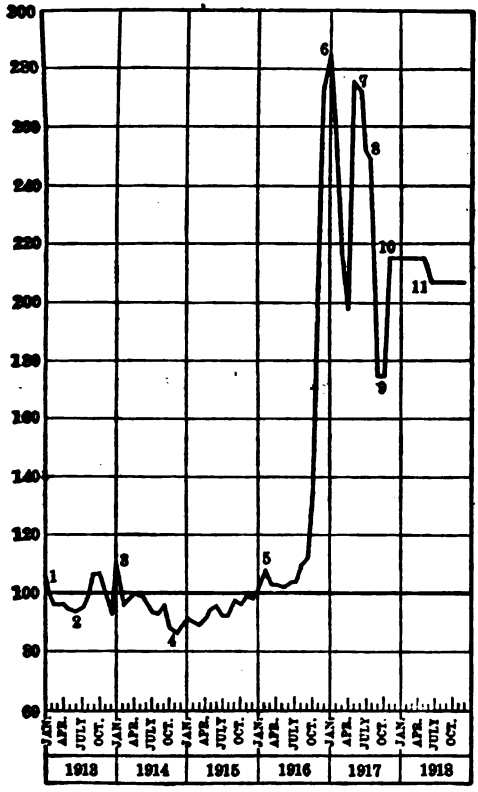

FIGURE 6.—Relative spot prices of bituminous coal produced in the Carterville and Franklin County district, Ill., by months, 1913–1918.

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MOUNT OLIVE DISTRICT, ILL.

Figure 8 shows the relative spot prices in this period compared with the average spot prices in the 12 months preceding the war, July, 1913, to June, 1914. Figure 7 shows the relative range in estimated average realization prices from all sales and includes both spot and contract transactions. The spot prices are taken from the St. Louis market quotations of the Coal Age and the average realization prices from annual reports of operators compiled by the Geological Survey. Tables of actual prices and of the computed relative prices from which these diagrams were drawn are given on pages 64–66.

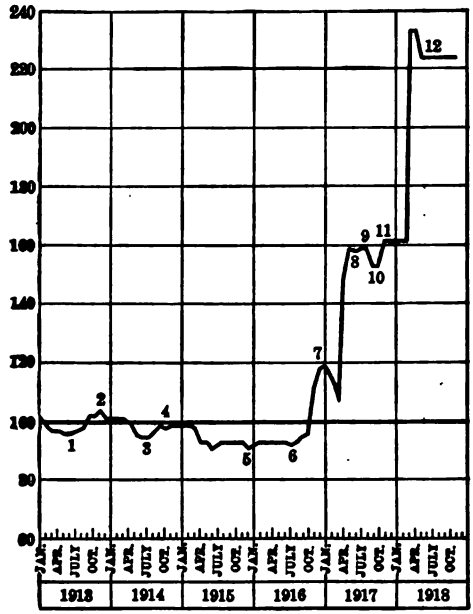

FIGURE 7.—Relative prices realized for bituminous coal produced in the Mount Olive district, Ill., by months, 1913–1918.

Production, 1917, 17,000,000 net tons. Average spot price, pre-war period, $1.24; average realized price $1.07.

1–6. The range of spot prices from summer to winter is, in normal times, marked in the Mount Olive district. In 1913 the lowest prices were in June, $1.03 (1), and the highest in November, $1.41 (2). In 1914 prices dropped to $1.05 in June (3), and rose to $1.26 in October and November (4). The lowest prices in 1915 were $1.04 in December (5) and the lowest in the summer of 1916, was $1.13 in July (6).

7. From September, 1916, to January, 1917, prices rose quickly, reaching a maximum for the six-year period of $3.25 in January, 1917 (7).

8. Prices prevailing in June, 1917, were quoted at $2.32 below the Peabody prices agreed upon as effective July 1 (8).

9. In July and August prices rose to $2.44 and $2.45, approaching the Peabody prices (9).

10. Prices fixed by the President toward the end of August are indicated at (10).

11. The advance of 45 cents authorized to cover the increase in wages of November, 1917, is shown at (11).

12. The general reduction of 10 cents a ton in the price of bituminous coal ordered by the Fuel Administrator, May 25, 1918, is indicated at (12).

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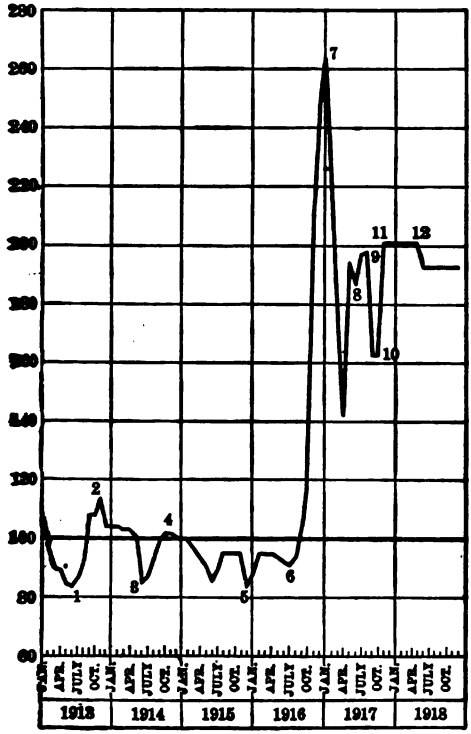

FIGURE 8.—Relative spot prices of bituminous coal produced in the Mount Olive district, Ill., by months, 1913–1918.

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SPRINGFIELD DISTRICT, ILL.

Figure 10 shows the relative spot prices in this period compared with the average spot prices in the 12 months preceding the war, July, 1913, to June, 1914. Figure 9 shows the relative range in estimated average realization prices from all sales and includes both spot and contract transactions. The spot prices are taken from the Chicago market quotations of the Coal Age and the average realization prices from annual reports of operators compiled by the Geological Survey. Tables of actual prices and of the computed relative prices from which these diagrams were drawn are given on pages 64–66.

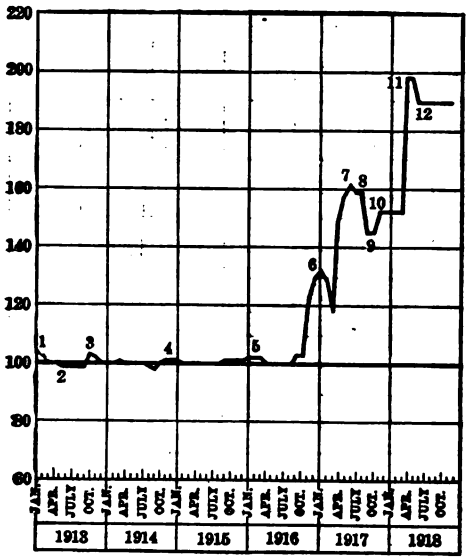

FIGURE 9.—Relative prices realized for bituminous coal produced in the Springfield district, Ill., by months, 1913–1918.

Production, 1917 (including Fulton, Peoria, and other northern districts), 27,000,000 net tons. Average spot price, pre-war period, $1.08; average realized price $1.26.

1–5. The spot prices for Springfield, Ill., coal in the period beginning with 1913 to the first half of 1916 ranged from $1.21 in January, 1913 (1), to $1.00 in May, 1913 (2), and $1.24 in February, 1916 (5). In October, 1913, the high point for the winter of 1913–14 was reached at $1.18 (3) and in the winter of 1914–15 the high quotation was reached in December, 1914, at $1.14 (4).

6. The price of Springfield coal began to rise in September, 1916, and reached a maximum of $3.52 in January, 1917 (6).

7. The spot prices for Springfield coal in June, 1917, averaged $3.05, slightly above the Peabody price fixed at the end of that month (7).

8. The prices in July and August under the Peabody agreement is shown at (8).

9. The reduction in price effected by the President's schedule is shown at (9).

10. The increase of 45 cents per ton allowed by the President to cover the advance in wages in November, 1917, is shown at (10).

11. The increase of 5 cents per ton in price of prepared sizes authorized on March 21, 1918, is shown at (11).

12. The general reduction of 10 cents per ton in the price of bituminous coal is shown at (12).

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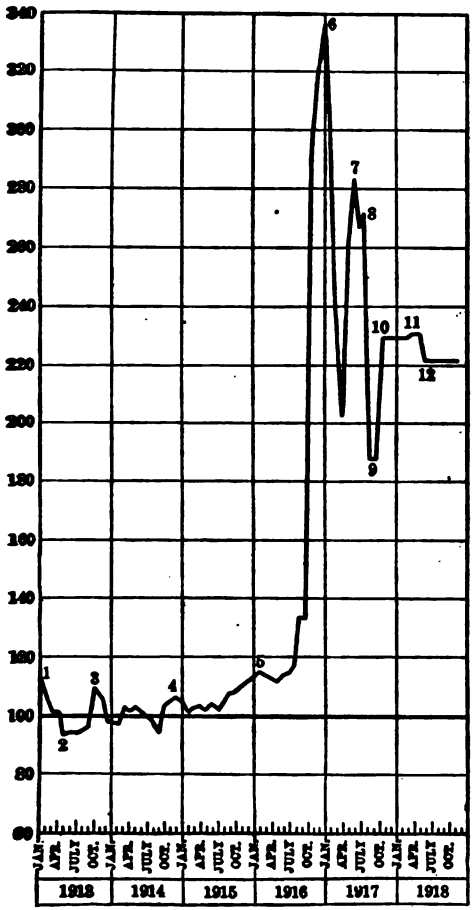

FIGURE 10.—Relative spot prices of bituminous coal produced in the Springfield district, Ill., by months, 1913–1918.

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STANDARD DISTRICT, ILL.

Figure 12 shows the relative spot prices in this period compared with the average spot prices in the 12 months preceding the war, July, 1913, to June, 1914. Figure 11 shows the relative range in estimated average realization prices from all sales and includes both spot and contract transactions. The spot prices are taken from the St. Louis market quotations of the Coal Age and the average realization prices from annual reports of operators compiled by the Geological Survey. Tables of actual prices and of the computed relative prices from which these diagrams were drawn are given on pages 64–66.

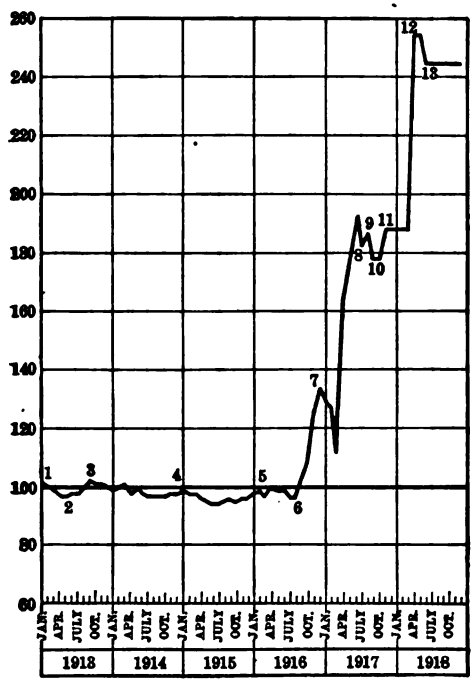

FIGURE 11.—Relative prices realized for bituminous coal produced in the Standard district, Ill., by months, 1913–1918.

Production, 1917, 13,000,000 net tons. Average spot price, prewar period, 91 cents; average realized price, 98 cents.

1–6. From the beginning of 1913 to the middle of 1916, the prices of Standard district coal varied with the season of the year, the lower prices prevailing in the summer period and the higher prices in the winter period. The curve for this period resembles in many respects that for prepared sizes of anthracite. The price in January, 1913, was quoted at 98 cents (1), in June and July at 83 cents (2), and in September 97 cents (3), which represents the maximum for the winter of 1913–14. The maximum for the winter of 1914–15 was reached in January, 1915, at 93 cents (4). The maximum for the winter of 1915–16 was reached in February, 1916, at $1.02 (5). The low price for the summer of 1916, was 86 cents in May (6).

7. In September, 1916, the price in coal from the Standard district began to rise and a maximum was reached in December, 1916, at $2.87 (7).

8. The price declined in the early part of 1917 and in April reached a minimum for the year of $1.31; in June was $1.73 (8).

9. The quotations for July and August did not reach the maximum set by the Peabody agreement, the price in August averaging $2.43 (9).

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10. The price fixed by the President on August 21, 1917, is shown at (10).
11. The advance of 45 cents authorized to cover the wage advance in November, 1917, is indicated at (11).

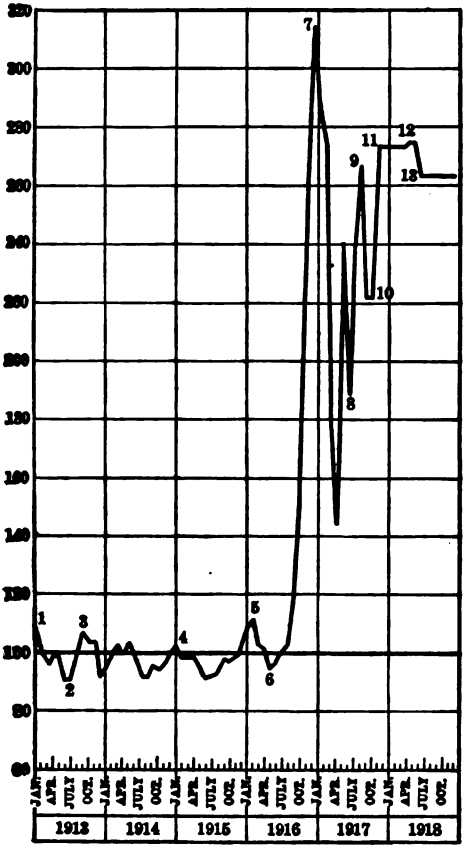

FIGURE 12.—Relative spot prices of bituminous coal produced in the Standard district, Ill., by months, 1913–1918.

12. An increase of 5 cents per ton on prepared sizes, authorized on March 21, 1918, is shown at (12).
13. The general reduction of 10 cents in the price of bituminous coal ordered on May 25, 1918, is shown at (13).

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CLINTON DISTRICT, IND.

Figure 14 shows the relative spot prices in the period compared with the average spot prices in the 12 months preceding the war, July, 1913, to June, 1914. Figure 13 shows the relative range in estimated average realization prices from all sales and includes both spot and contract transactions. The spot prices are taken from the Chicago market quotations of the Coal Age and the average realization prices from annual reports of operators compiled by the Geological Survey. Tables of actual prices and of the computed relative prices from which these diagrams were drawn are given on pages 64–66.

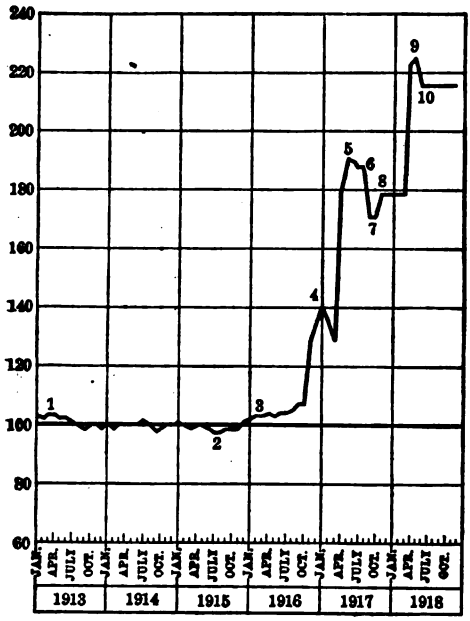

FIGURE 13.—Relative prices realized for bituminous coal produced in the Clinton district, Ind., by months, 1913–1918.

Production of State of Indiana, 1917, 26,500,000 net tons. Average spot price, pre-war period, $1.13; average realized price, $1.10.

1, 2, and 3. The price of Clinton coal ranged from $1.25 in April, 1913 (1), to $1.03 in July and August, 1915 (2), and $1.23 in February, 1916 (3), in the period before the general rise in the prices of bituminous coal that took place in the latter part of 1916.

4. The rise in price of Clinton coal that began in August and September, 1916, reached a maximum in January, 1917, of the average spot price in that month of $3.57 (4).

5. In May and June, 1917, spot prices for Clinton coal were around $3.12 (5).

6. The Peabody prices (6) were slightly lower than the maximum quotations in May and June.

7. The prices fixed by the President are indicated at (7).

8. The increase of 45 cents per ton allowed operators to cover the advance in wages in November is shown at (8).

9. An advance of 5 cents per ton on prepared sizes, authorized by the Fuel Administrator on May 1, 1918, is indicated at (9).

10. The general reduction of 10 cents per ton in the price of bituminous coal ordered by the Fuel Administrator on May 25, 1918, is shown at (10).

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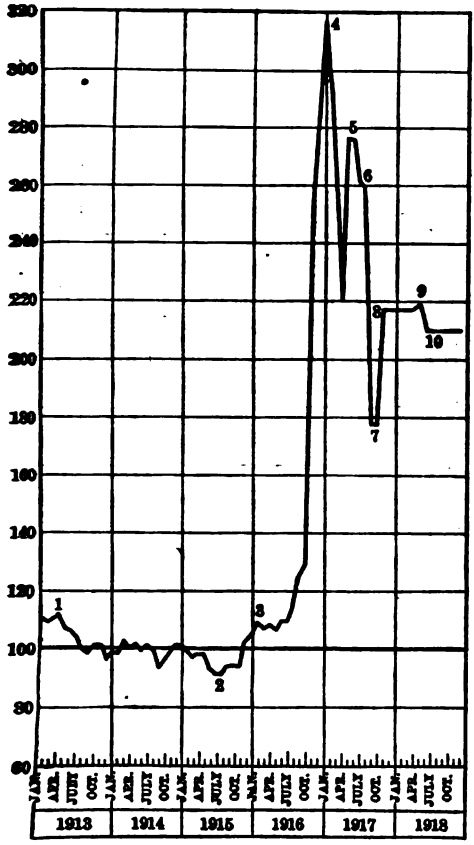

FIGURE 14.—Relative spot prices of bituminous coal produced in the Clinton district, Ind., by months 1913-1918.

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EASTERN KENTUCKY.

Figure 16 shows the relative spot prices in this period compared with the average spot prices in the 12 months preceding the war, July 1913, to June, 1914. Figure 15 shows the relative range in estimated average realization prices from all sales and includes both spot and contract transactions. The spot prices are taken from the Louisville market quotations of the Coal Age and the average realization prices from annual reports of operators compiled by the Geological Survey. Tables of actual prices and of the computed relative prices from which these diagrams were drawn are given on pages 64–66.

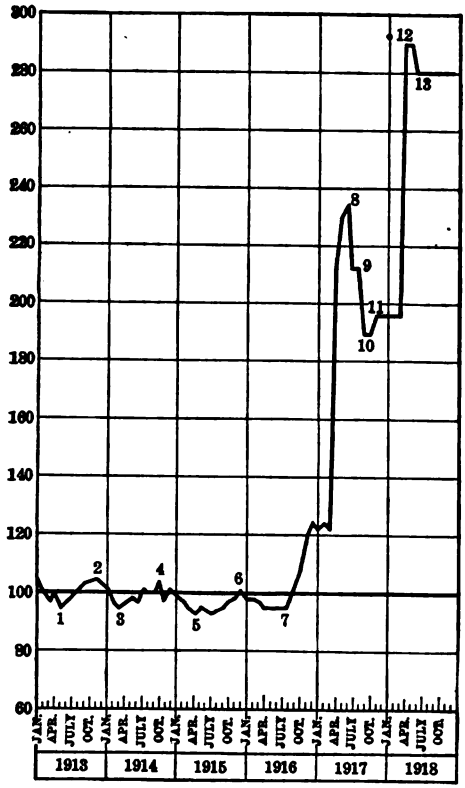

FIGURE 15.—Relative prices realized for bituminous coal produced in the eastern Kentucky district, by months, 1913–1918.

Production, 1917, 17,000,000 net tons. Average spot price, prewar period, $1.52; average realized price, $1.11.

1–7. The seasonal character of the market for eastern Kentucky coal is well shown by the diagram for the period 1913 to the middle of 1916. The low points (1, 3, 5, and 7) occurred in the summer time and the high points (2, 4, and 6) in the fall and winter time. The highest spot price reached in the years 1913–1915 was in November, 1913, $1.89. The maximum in the winter of 1914–15 was in October, 1914, $1.58 (4). The maximum reached in 1915 was $1.71 in December (6). The lowest price in 1913 was $1.29 in May (1); the lowest price in 1914 was $1.23 in April (3), and the lowest price in 1915 and in the six-year period covered in this report was $1.16 in March, 1915 (5). From the high level of December, 1915, the spot prices of eastern Kentucky coal declined to $1.33 in May and June, 1916 (7).

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8. The spot price for eastern Kentucky coal began to rise in September, 1916, and in December reached a maximum for that year of $4.17. The following June the price reached $4.72, the highest average monthly quotation recorded in the six-year period (8).

9. The Peabody price was quoted in July and August (9).

10. The prices fixed by the President on August 21, 1917, are shown at (10).

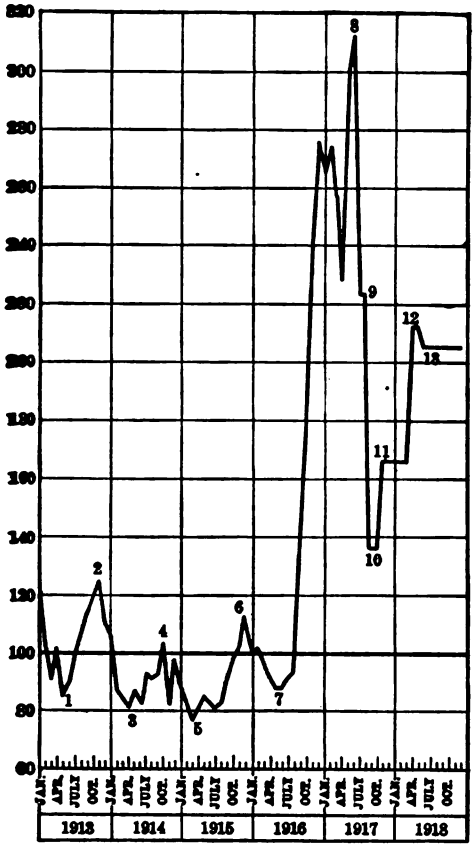

FIGURE 16.—Relative spot prices of bituminous coal produced in the eastern Kentucky district, by months, 1913–1918.

11. The wage increase of November, 1917, for which the operators were permitted to add 45 cents per ton to the price of coal at the mine is indicated at (11).

12. An increase of 70 cents per ton on all sizes was authorized by the Fuel Administrator on April 4, 1918 (12).

13. The general reduction of 10 cents per ton in the average price of bituminous coal is shown at (13).

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WESTERN KENTUCKY.

Figure 18 shows the relative spot prices in this period compared with the average spot prices in the 12 months preceding the war, July, 1913, to June, 1914. Figure 17 shows the relative range in estimated average realization prices from all sales and includes both spot and contract transactions. The spot prices are taken from the Louisville market quotations of the Coal Age and the average realization prices from annual reports of operators compiled by the Geological Survey. Tables of actual prices and of the computed relative prices from which these diagrams were drawn are given on pages 64–66.

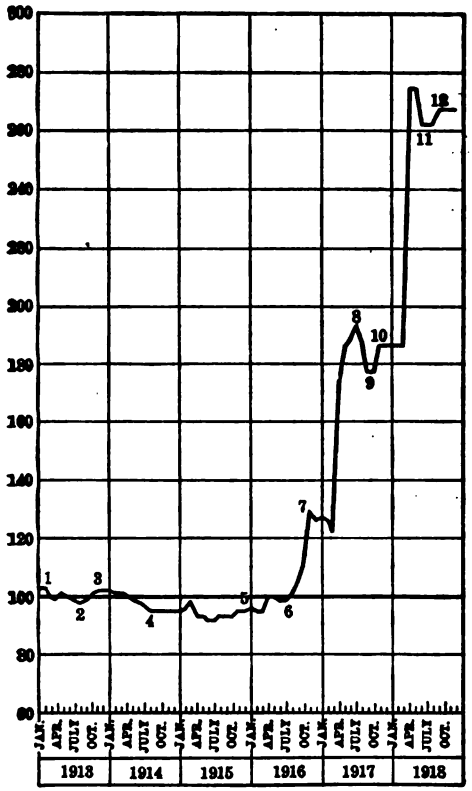

FIGURE 17.—Relative prices realized for bituminous coal produced in the western Kentucky district, by months, 1913-1918.

Production, 1917, 10,000,000 net tons. Average spot price, prewar period, 98 cents; average realized price, 89 cents.

1–6. From the beginning of 1913 to the middle of 1916, when the general rise in the prices of bituminous coal began, the highest price of free coal quoted for western Kentucky was in January, 1913, $1.12 (1). In the summer of 1913 the spot price of western Kentucky coal declined to 88 cents in August (2) and rose again to $1.07 in November and December (3). From this point the price declined steadily to a low point for the period under discussion of 81 cents in October, 1914 (4). In the spring of 1915 the price rose, and after a small recession during the summer of 1915, increased to a maximum of $1.06 in January, 1916 (5). The price again declined to a minimum in 1916 of 86 cents a ton in July (6).

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7. From August to November, 1916, the price rose to a maximum of $2.70 (7). The spot price, however, declined to $1.72 in April, 1917, and had risen to but $2.62 in June, when the Peabody price was fixed at $3 for western Kentucky coal.

8. The western Kentucky coal was not quoted in July at the maximum established by the Peabody agreement, but rose only to $2.81 (8).

9. The price fixed by the President is indicated at (9).

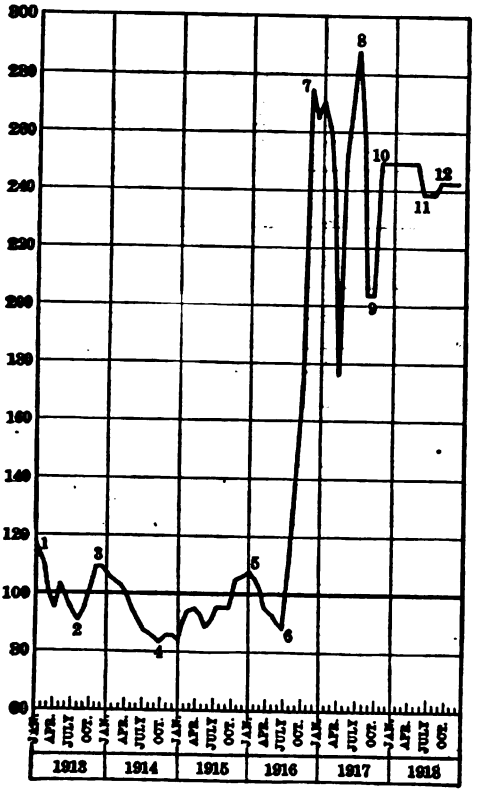

FIGURE 18.—Relative spot prices of bituminous coal produced in the western Kentucky district, by months, 1913–1918.

10. The wage advance in November, to cover which the operators were permitted to add 45 cents a ton at the mine, is shown at (10).

11. The general reduction of 10 cents per ton in the price of bituminous coal on May 25, 1918, is indicated at (11).

12. On August 23, 1918, the Fuel Administrator authorized an advance of 5 cents per ton on run-of-mine and prepared sizes indicated at (12).

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GEORGES CREEK DISTRICT, MD.

Figure 20 shows the relative spot prices in this period compared with the average spot prices in the 12 months preceding the war, July, 1913, to June, 1914. Figure 19 shows the relative range in estimated average realization prices from all sales and includes both spot and contract transactions. The spot prices are taken from the Boston market quotations of the Coal Age and the average realization prices from annual reports of operators compiled by the Geological Survey. Tables of actual prices and of the computed relative prices from which these diagrams were drawn are given on pages 64–66.

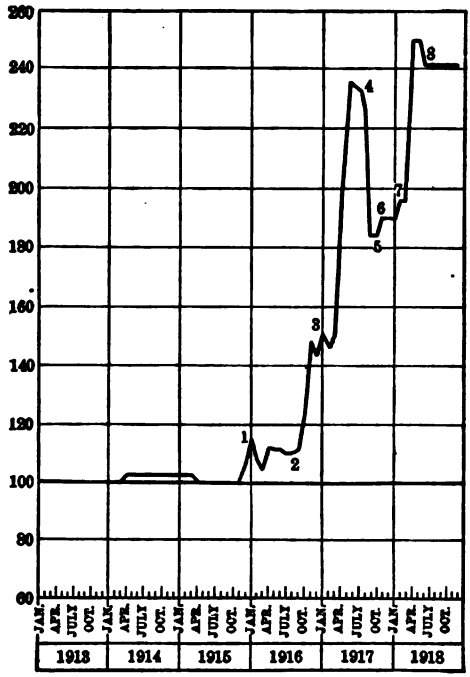

FIGURE 19.—Relative prices realized for bituminous coal produced in the Georges Creek district, Md., by months, 1913–1918.

Production, 1917, 4,000,000 net tons. Average spot price, pre-war period, $1.54; average realized price, $1.14.

1, 2. The quotations carried on the Boston market for Georges Creek coal were uniformly $1.54 through 1913, 1914, and until the end of 1915. In January, 1916, the price rose to $2.50 (1), but declined from the first part of 1916 to $1.47 in August (2).

3, 4. Beginning with September, 1916, the price rose rapidly and reached a maximum of $5.72 in January, 1917, around which the price fluctuated until in June, at the time the Peabody prices were fixed, Georges Creek was quoted in Boston at $5.55. The prices in July and August were $5.46 and $5, indicated at (4).

5. The prices fixed by the President on August 21, 1917, represent a considerable drop below the prevailing quotations (5).

6. The advance of 45 cents per ton authorized to cover the increase in wages in November, 1917, are indicated at (6).

7. On January 31, 1918, an advance of 40 cents per ton on all sizes was authorized by the Fuel Administrator (7).

8. The general reduction of 10 cents per ton ordered by the Fuel Administrator on May 25, 1918, is indicated at (8).

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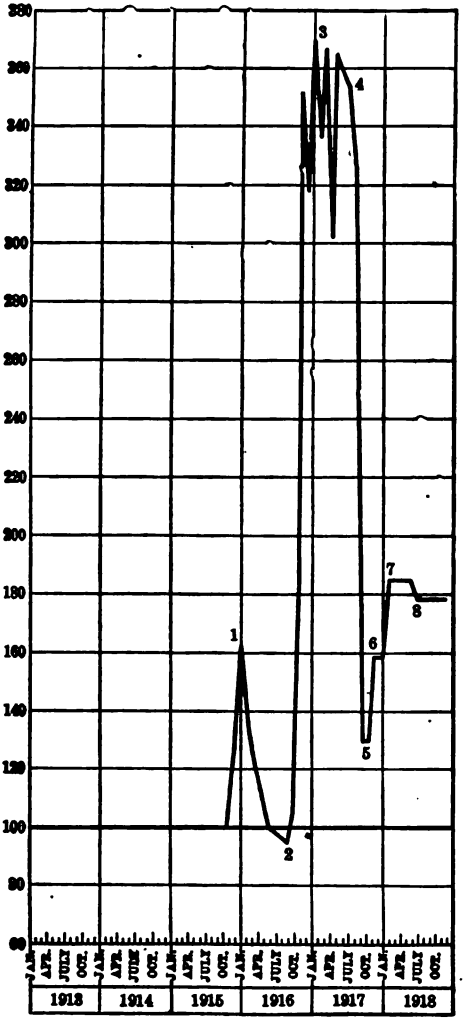

FIGURE 20.—Relative spot prices of bituminous coal produced in the Georges Creek district, Md., by months, 1913–1918.

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HOCKING DISTRICT, OHIO.

Figure 22 shows the relative spot prices in this period compared with the average spot prices in the 12 months preceding the war, July, 1913, to June, 1914. Figure 21 shows the relative range in estimated average realization prices from all sales and includes both spot and contract transactions. The spot prices are taken from the Columbus and Detroit market quotations of the Coal Age and the average realization prices from annual reports of operators compiled by the Geological Survey. Tables of actual prices and of the computed relative prices from which these diagrams were drawn are given on pages 64–66.

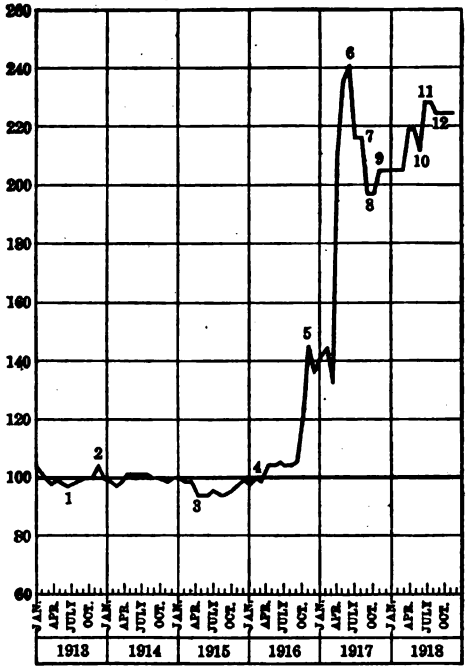

FIGURE 21.—Relative prices realized for bituminous coal produced in the Hocking district, Ohio, by months, 1913–1918.

Production, 1917 (including all of southern Ohio), 14,000,000 net tons. Average spot price, pre-war period, $1.19; average realized price, $1.16.

1–4. Spot prices for southern Ohio coal were generally higher than in the No. 8 district in 1913–1915, the highest, $1.41, in November, 1913 (2), following the low price of $1.10 in June (1), and succeeded by the lowest in the three years of $1.06 in March, 1915 (3). A slow but steady increase in prices is noted through the last three-quarters of 1915 that reached $1.25 in February, 1916 (4).

5, 6. A dull market in the early part of the summer of 1916 was enlivened when early in August a flood on Cabin Creek, W. Va., disabled a considerable portion of the Kanawha field. Consumers in Ohio with contracts in this field began bidding for coal on the Columbus market and prices of Hocking coal began to rise, under the stimulation of this movement, in September. The highest spot price was recorded in November, $4.74 (5). The spot price fluctuated greatly during the winter and spring of 1917 and was at $4.32 (6) in June when the Peabody price was fixed.

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7. The drop from the June price to the Peabody price is shown at (7).
8. The President's price (8) was considerably below the Peabody agreement.
9. The wage advance in November, for which the operators were allowed to add 45 cents a ton to the mine price, is shown at (9).

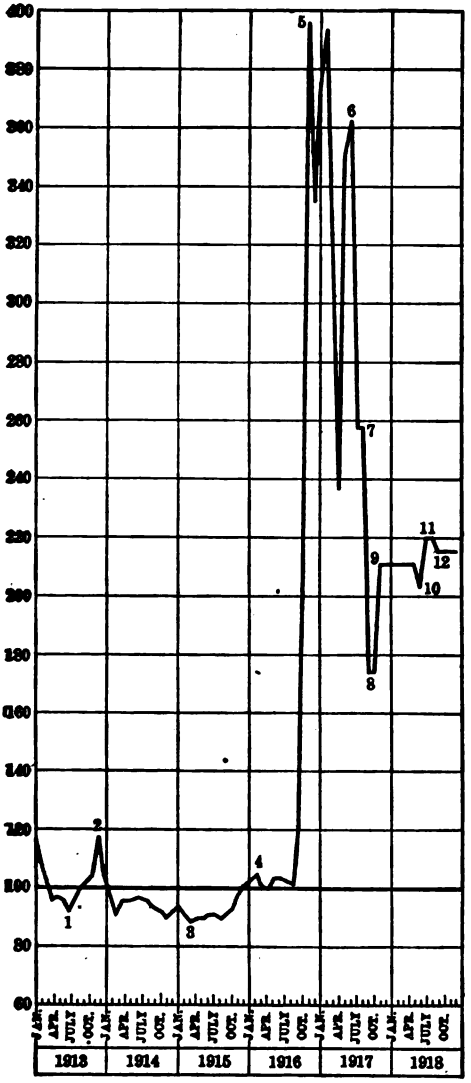

FIGURE 22.—Relative spot prices of bituminous coal produced in the Hocking district, Ohio, by months, 1913–1918.

10. The general reduction of 10 cents per ton, May 25, 1918, is shown at (10).
11. The order of June 29, 1918, permitted an increase of 20 cents a ton on all sizes of Hocking coal (11).
12. These prices were reduced 5 cents a ton by the order of August 23, 1918 (12).

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PITTSBURGH NO. 8 DISTRICT, OHIO.

Figure 24 shows the relative spot prices in this period compared with the average spot prices in the 12 months preceding the war, July, 1913, to June, 1914. Figure 23 shows the relative range in estimated average realization prices from all sales and includes both spot and contract transactions. The spot prices are taken from the Columbus and Detroit market quotations of the Coal Age and the average realization prices from annual reports of operators compiled by the Geological Survey. Tables of actual prices and of the computed relative prices from which these diagrams were drawn are given on pages 64–66.

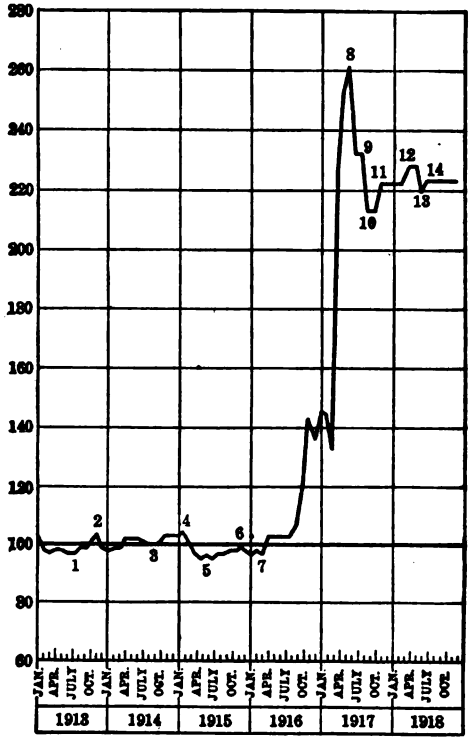

FIGURE 23.—Relative prices realized for bituminous coal produced in the Pittsburgh No. 8 district, Ohio, by months, 1913–1918.

Production, 1917 (including northern Ohio), 25,000,000 net tons. Average spot price, pre-war period, $1.12; average realized price, $1.09.

1–7. The spot price of Ohio No. 8 coal in the years 1913–1915 ranged from 98 cents to $1.28 a ton. In 1913 the low point was in July (1) at $1.03 a ton and the high point at $1.28 in November (2). From this figure in November, 1913, the price declined to $1.02 in August and September, 1914 (3), and during the winter advanced to $1.17 in February, 1915 (4), the highest point during that year. The lowest price recorded in the six-year period 1913–1918 was in May, 1915, 98 cents (5). Prices rose slowly during the summer and fall of 1915 to $1.12 in December (6) but receded to $1.06 in March, 1916.

8 and 9. With the beginning of the coal year, 1916–1917, prices of coal in this district rose slightly, but the spectacular rise did not begin until September. By November the prices had risen to $4.74, and in January, 1917, the maximum of $4.93 was reached (8). A drop in April to $2.76 was followed by a new rise to $4.37 in June (9).

10. The Peabody price of $3 was agreed upon, effective July 1, 1917 (10), and this price was quoted during July and in August until the President fixed prices.

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11. The price fixed by the President, August 21, was at a $2 base for mine-run coal (11).

12. The wage advance, for which 45 cents a ton was allowed the operator, is shown at (12).

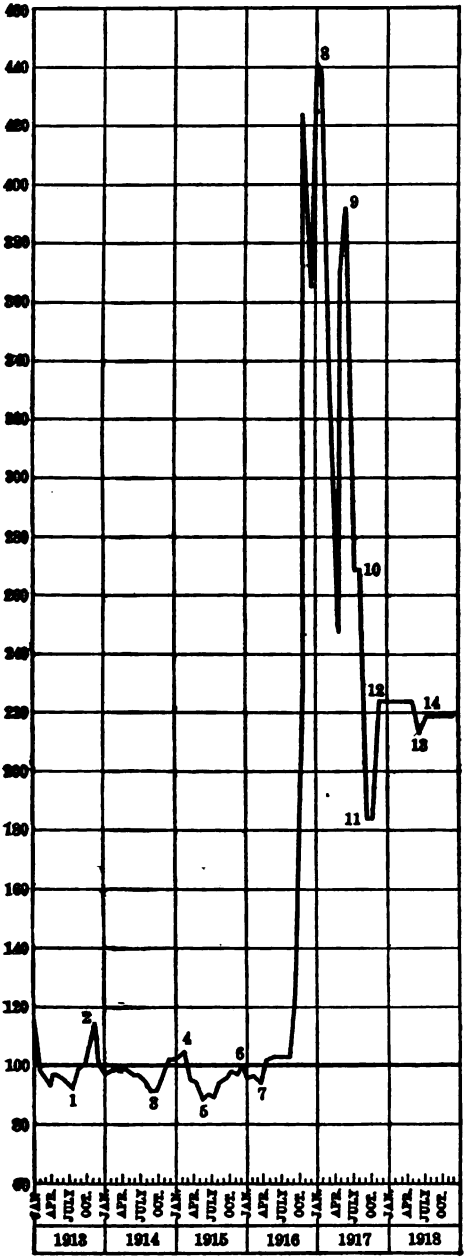

FIGURE 24.—Relative spot prices of bituminous coal produced in the Pittsburgh No. 8 district, Ohio, by months, 1913–1918.

13. The general reduction of 10 cents in the price of all bituminous coal on May 25 is shown at (13).

14. An increase of 25 cents a ton on slack coal on June 29, 1918 is recorded at (14).

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CLEARFIELD DISTRICT, PA.

Figure 26 shows the relative spot prices in this period compared with the average spot prices in the 12 months preceding the war, July, 1913, to June, 1914. Figure 25 shows the relative range in estimated average realization prices from all sales and includes both spot and contract transactions. The spot prices are taken from the Boston market quotations of the Coal Age and the average realization prices from annual reports of operators compiled by the Geological Survey. Tables of actual prices and of the computed relative prices from which these diagrams were drawn are given on pages 67–69.

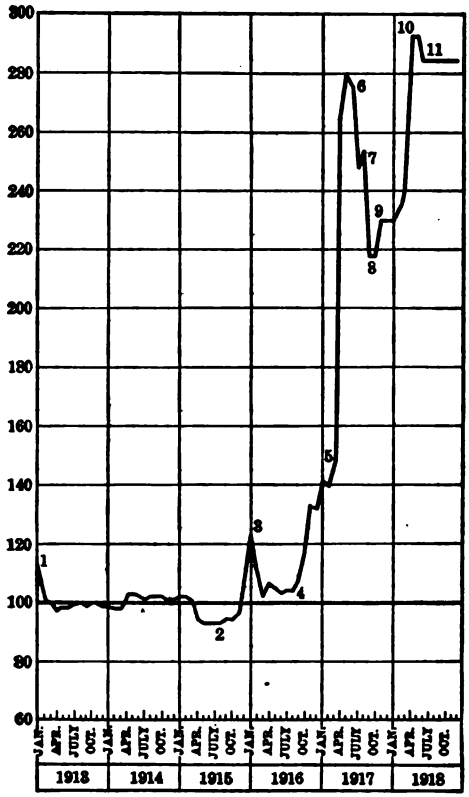

FIGURE 25.—Relative prices realized for bituminous coal produced in the Clearfield district, Pa., by months, 1913–1918.

Production, 1917, 30,000,000 net tons. Average spot price, pre-war period, $1.12; average realized price, $1.04.

1–4. From $1.71 in January, 1913 (1), current quotations on Clearfield coal dropped to an average in the remainder of 1913, through 1914, and until November, 1915, of around $1.05 and $1.15. The lowest point reached was in the period from May to August, 1915, $1 (2). In January, 1916, the price rose to $2.59 (3), but declined again to $1.16 in June (4).

5. Prices began to rise rapidly in August, 1916, and reached a maximum of $5.16 in March, 1917 (5).

6. The price in June, when the Peabody prices were agreed upon, was quoted at $4.89 (6).

7. The prices in July and August, 1917, during the period in which the Peabody agreement was in effect, are indicated at (7).

8. Prices fixed by the President in August are shown at (8).

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9. The increase of 45 cents a ton allowed to cover the wage advance of November, 1917, is indicated at (9).

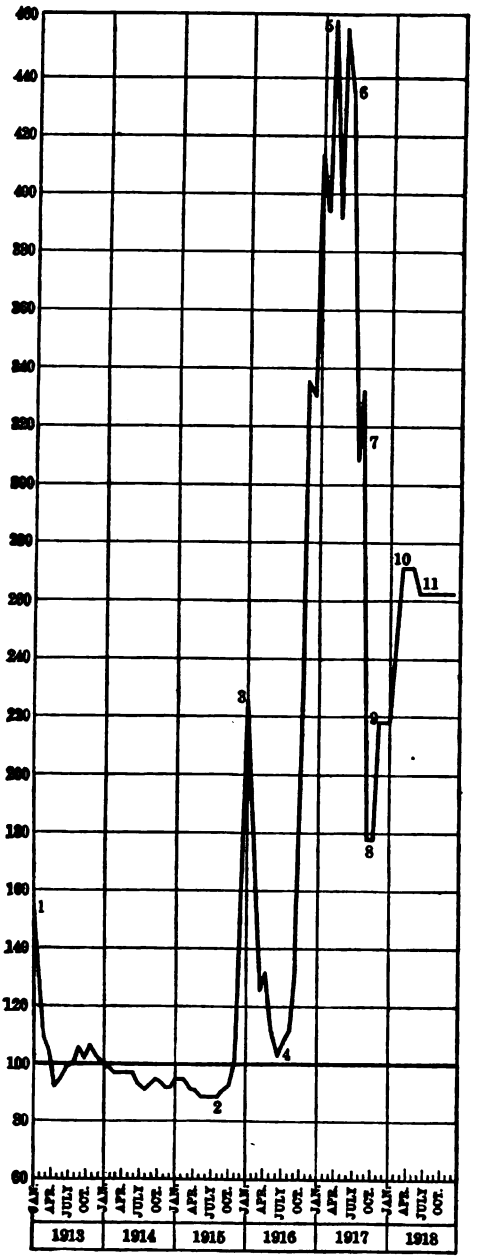

FIGURE 26.—Relative spot prices of bituminous coal produced in the Clearfield district, Pa., by months, 1913–1918.

10. The increase allowed central Pennsylvania by the Fuel Administrator February 16, 1918, raised the price 60 cents a ton (10).

11. The general reduction of 10 cents a ton in the price of bituminous coal by the Fuel Administrator May 25, 1918, is shown at (11).

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PITTSBURGH DISTRICT, PA.

Figure 28 shows the relative spot prices in this period compared with the average spot prices in the 12 months preceding the war, July, 1913, to June, 1914. Figure 27 shows the relative range in estimated average realization prices from all sales and includes both spot and contract transactions. The spot prices are taken from the Pittsburgh market quotations of the Coal Age and the average realization prices from annual reports of operators compiled by the Geological Survey. Tables of actual prices and of the computed relative prices from which these diagrams were drawn are given on pages 67-69.

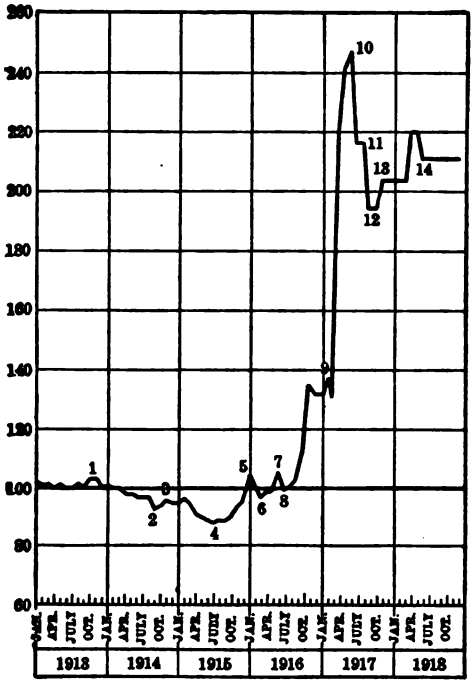

FIGURE 27.—Relative prices realized for bituminous coal produced in the Pittsburgh district, Pa., by months, 1913–1918.

Production, 1917, 51,000,000 net tons. Average spot price, pre-war period, $1.26; average realized price, $1.12.

1–4. The spot price of Pittsburgh coal declined from $1.36 in October and November, 1913 (1), to 93 cents in July, 1915 (4), with a temporary rise in the winter of 1914–15 from $1 in September (2) to $1.14 in November, 1914 (3).

5–8. In the winter of 1915–16 and again in the summer of 1916 there were temporary rises in price. Quotations in Januray, 1916, were $1.58 (5), followed by $1.23 in April (6) and a high mark for the summer period of $1.72 in June (7). Prices declined again to $1.34 in July (8).

9. By October, 1916, prices were again well on the upward trend and in February, 1917, reached the maximum for the six-year period of $5.21 (9).

10. In June, when the Peabody prices were agreed upon, quotations averaged $4.97 (10).

11. The Peabody prices are indicated at (11).

12. The prices fixed by the President are shown at (12).

13. The increase of 45 cents per ton allowed to cover the advance in wages is shown at (13).

14. The general reduction of 10 cents a ton on all bituminous coal ordered May 25, 1918, is indicated at 14).

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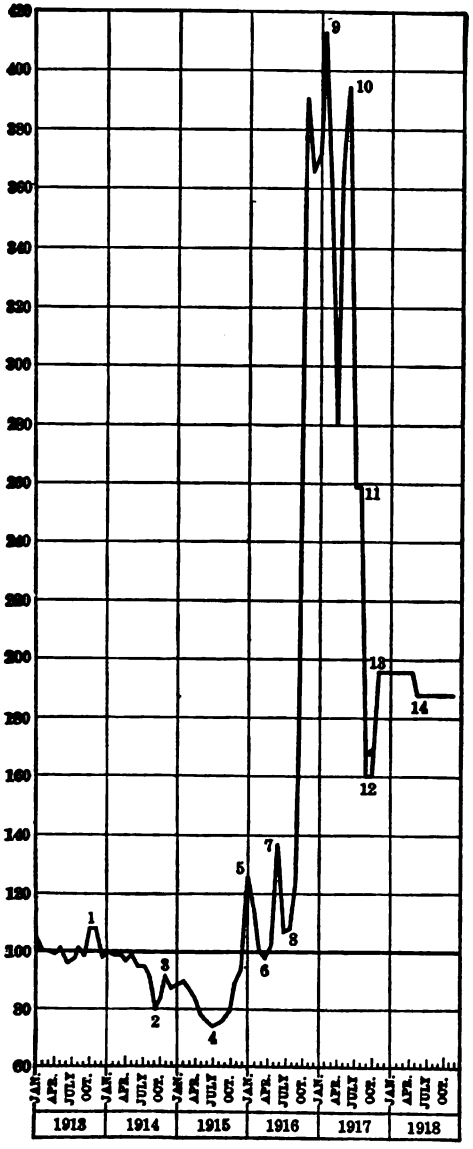

FIGURE 28.—Relative spot prices of bituminous coal produced in the Pittsburgh district, Pa., by months, 1913–1918.

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SOMERSET AND CAMBRIA COUNTIES, PA.

Figure 30 shows the relative spot prices in this period compared with the average spot prices in the 12 months preceding the war, July, 1913, to June, 1914. Figure 29 shows the relative range in estimated average realization prices from all sales and includes both spot and contract transactions. The spot prices are taken from the Boston market quotations of the Coal Age and the average realization prices from annual reports of operators compiled by the Geological Survey. Tables of actual prices and of the computed relative prices from which these diagrams were drawn are given on pages 67-69.

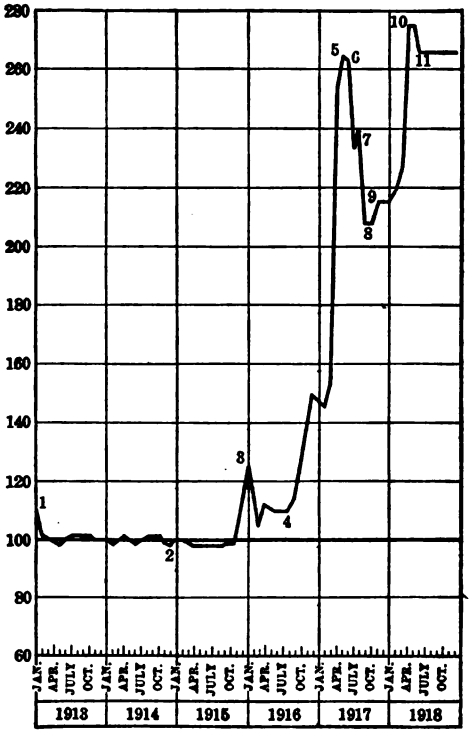

FIGURE 29.—Relative prices realized for bituminous coal produced in Somerset and Cambria counties, Pa., by months, 1913-1918.

Production, 1917, 29,000,000 net tons. Average spot price, pre-war period, $1.30; average realized price, $1.11.

1-4. From $1.88 in January, 1913 (1), current quotations on Somerset and Cambria coal dropped to an average in the remainder of 1913, through 1914, and until November, 1915, of around $1.25. The lowest point reached was in December, 1914, $1.18 (2). In January, 1916, the price rose to $2.79 (3), but declined again to $1.38 in June and July (4).

5. Prices began to rise rapidly in August, 1916, and reached a maximum of $5.48 in March, 1917 (5).

6. The price in June, 1917, when the Peabody prices were agreed upon, was quoted at $5.11 (6).

7. The prices in July and August, 1917, during the period in which the Peabody agreement was in effect, are indicated at (7).

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8. Prices fixed by the President in August are shown at (8).
9. The increase of 45 cents a ton allowed to cover the wage advance of November, 1917, is indicated at (9).

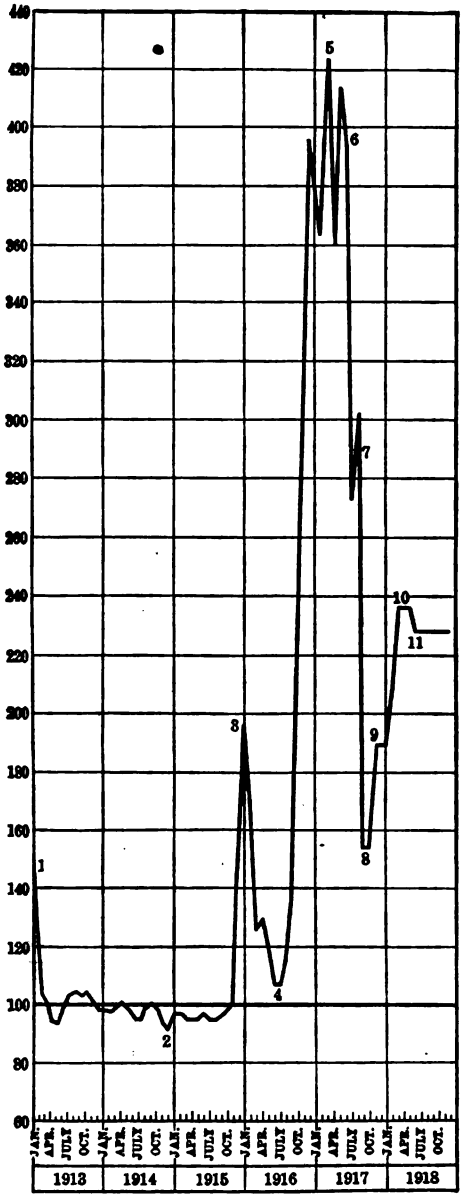

FIGURE 30.—Relative spot prices of bituminous coal produced in Somerset and Cambria counties, Pa., by months, 1913–1918.

10. The increase allowed central Pennsylvania by the Fuel Administrator February 16, 1918, raised the price 60 cents a ton (10).
11. The general reduction of 10 cents a ton in the price of bituminous coal by the Fuel Administrator May 25, 1918, is shown at (11).

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KANAWHA DISTRICT, W. VA.

Figure 32 shows the relative spot prices in this period compared with the average spot prices in the 12 months preceding the war, July, 1913, to June, 1914. Figure 31 shows the relative range in estimated average realization prices from all sizes and includes both spot and contract transactions. The spot prices are taken from the Columbus, Ohio, market quotations of the Coal Age and the average realization prices from annual reports of operators compiled by the Geological Survey. Tables of actual prices and of the computed

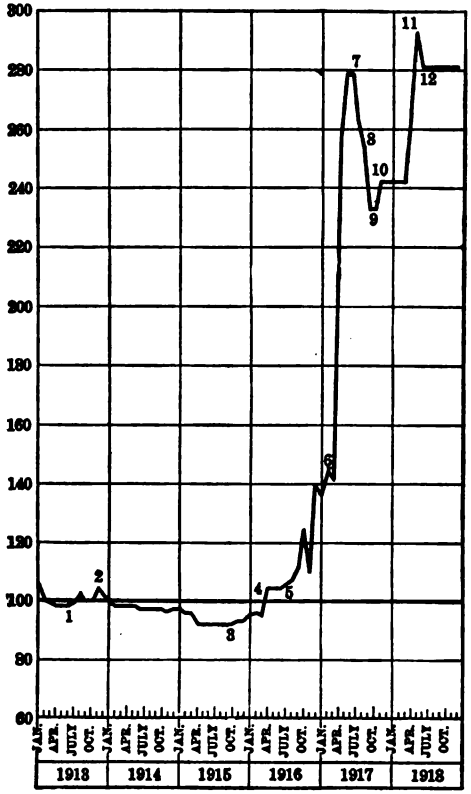

FIGURE 31.—Relative prices realized for bituminous coal produced in the Kanawha district, W. Va., by months, 1913–1918.

relative prices from which these diagrams were drawn are given on pages 67-69.

Production, 1917 (including Logan and Kenova-Thacker), 28,000,000 net tons. Average spot price, pre-war period, $1.16; average realized price 94 cents.

1–5. From a spot price of $1.39 in January, 1913, the price of Kanawha coal dropped to $1.06 in June (1) and rose to $1.37 in November (2). From this peak the price declined in 1914, reaching a minimum of $1.02 in the summer of 1915 (3). In the winter of 1915–16 the price rose to $1.20 in February (4). From April to August the price ranged from 96 cents to $1.21. There was a sudden upward rise of prices in the Kanawha district again in September, in which the average spot price was $1.59.

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6, 7. The maximum in the period of high prices was reached in February, 1917, in which month the average spot price was $4.15. The price dropped off in March and April but in May again reached $4.15 and in June was $4.11 (7).

8. The Peabody agreement brought the price for free coal in the Kanawha district to around $3.00 (8).

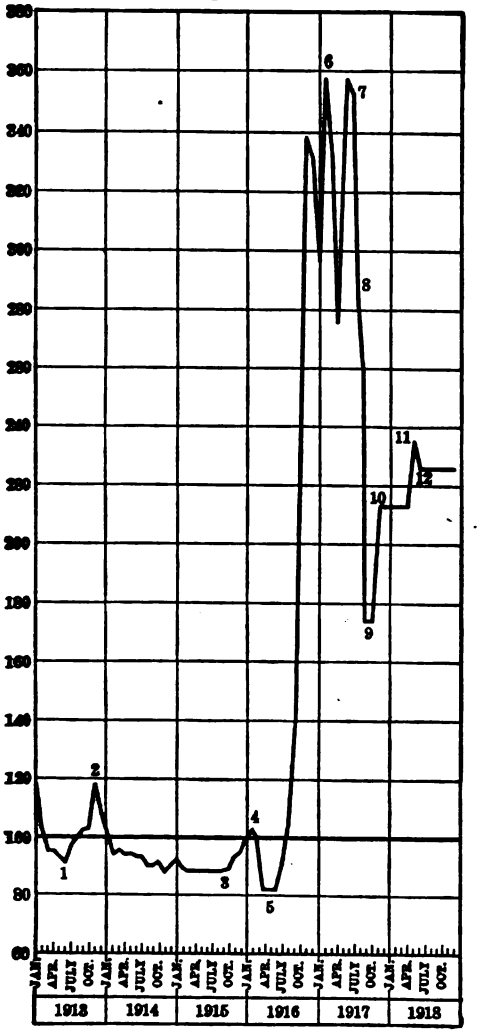

FIGURE 32.—Relative spot prices of bituminous coal produced in the Kanawha district, W. Va., by months, 1913–1918.

9. The prices fixed by the President on August 21, 1917, were considerably below those agreed upon in June by the Lane-Peabody committee (9).

10. The increase in wages authorized in November, to cover which the operators were permitted to add 45 cents a ton, is shown at (10).

11. On April 20, 1918, the Fuel Administrator authorized an increase in price of Kanawha coal of 25 cents a ton on all sizes (11).

12. The general reduction in all mine prices for bituminous coal of 10 cents a ton, ordered on May 25, 1918, is shown at (12).

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POCAHONTAS AND NEW RIVER FIELDS, W. VA.

Figure 34 shows the relative spot prices in this period compared with the average spot prices in the 12 months preceding the war, July, 1913, to June, 1914. Figure 33 shows the relative range in estimated average realization prices from all sales and includes both spot and contract transactions. The spot prices are taken from the Boston market quotations of the Coal Age and the average realization prices from annual reports of operators compiled by the Geological Survey. Tables of actual prices and of the computed relative prices from which these diagrams were drawn are given on pages 67–69.

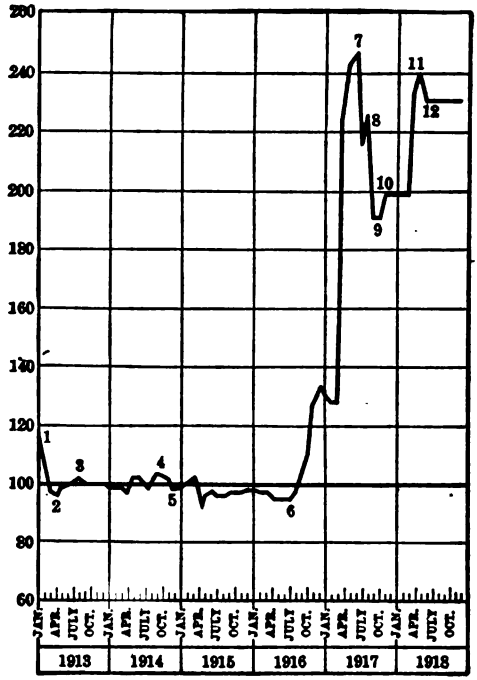

FIGURE 33.—Relative prices realized for bituminous coal produced in the Pocahontas and New River fields, W. Va., by months, 1913–1918.

Production, 1917, 40,000,000 net tons. Average spot price, pre-war period, $1.30; average realized price, $1.08.

1–6. The highest spot price for Pocahontas and New River coal in the years 1913–1915 was $1.85 in January, 1913 (1). The price rapidly dropped, however, to $1.16 in March (2), but recovered to the maximum for the remaining portion of the three years of $1.39 in July, 1913 (3). From this point the price suddenly declined until $1.12 was reached in July, 1914. The price rose to $1.33 in September, 1914 (4), but declined to $1.09 and $1.10 in November and December (5). With some fluctuations the price rose to $1.30 in January, 1916. The price declined from January, 1916, to June, the average price in June being $1.24 (6).

7. The prices of smokeless coal began to advance in July, 1916, and in August reached $1.54 and by December was quoted at $5.30. The maximum was reached in June, 1917, at $5.34 (7).

8. The Peabody prices were quoted in July, but under the pressure of buyers the quotations in August, 1917, were above the Peabody agreement (8).

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9. The prices fixed by the President on August 21, 1917, was considerably below the Peabody price (9).

10. The advance in wages authorized in November, to cover which the operators were permitted to add 45 cents a ton, is shown at (10).

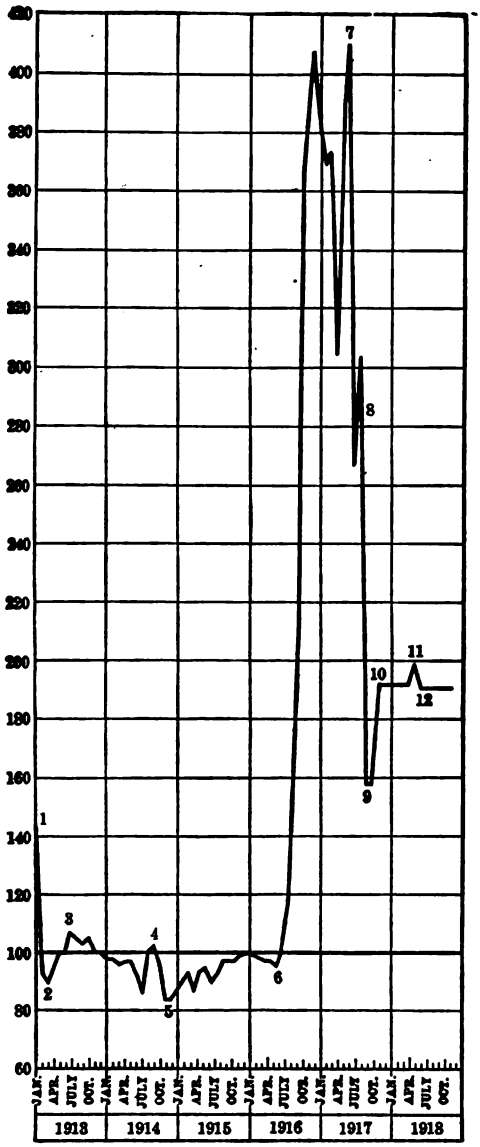

FIGURE 34.—Relative spot prices of bituminous coal produced in the Pocahontas and New River fields, W. Va., by months 1913–1918.

11. An increase of 20 cents a ton authorized for the New River district but not for the Pocahontas district, effective April 19, 1918, is shown at (11).

12. The general reduction of 10 cents a ton at the mine in all prices of bituminous coal, ordered by the Fuel Administrator on May 25, is shown at (12).

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ALABAMA.

Figure 35 shows the relative spot prices in this period, compared with the average spot prices in the 12 months preceding the war, July, 1913, to June, 1914. The spot prices from January, 1913, to June, 1917, represent a weighted average of a series of quotations for high and low grade steam coal obtained through the courtesy of S. L. Yerkes, of Birmingham, Ala.

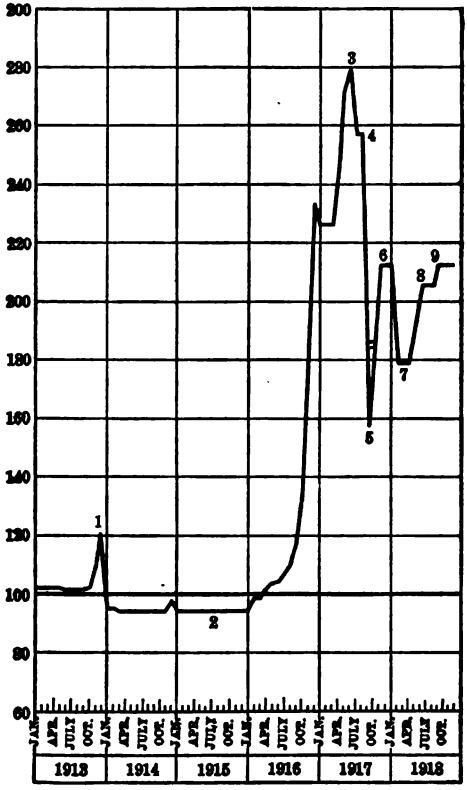

FIGURE 35.—Relative spot prices of Alabama steam coal, by months, 1913-1918.

Production of coal in Alabama in 1917, 20,000,000 net tons. Average spot price of steam coal, pre-war period, $1.33.

1, 2. A maximum average price of $1.61 (1) was quoted in December, 1913, for the three years, 1913, 1914, and 1915. Through 1915 the price did not vary from an average of $1.25 (2).

3. Beginning early in 1916, the price of steam coal in Alabama steadily rose, reaching a maximum in December of $3.11. After a temporary decline, the price rose to $3.71 (3) in June, 1917, the maximum in the six-year period.

4. The Peabody prices were established in July and are shown at (4).

5. The drop to the level set by the President's prices of August 21, 1917, is shown at (5).

6. On October 1, 1917 an increase in mine prices of Alabama coal was authorized by the Fuel Administrator and on October 29 (6) an increase of 45 cents a ton was allowed to cover the advance in wages allowed November 1.

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7. On February 6 the 45 cent increase was taken off and the average price was decreased to (7).

8. Effective May 15, 1918, producers in Alabama were again permitted to add the 45 cents a ton to cover increased wages. May 25 the price was reduced 10 cents with all other bituminous districts. The average for the month is indicated at (8).

9. Changes in price of Alabama coal effected by the order of August 22, 1918, are indicated at (9).

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TABLES OF PRICES AND RELATIVE PRICES.

Spot prices of bituminous coal and coke reduced to average realization base, f. o. b. mines, 1913–1918.

[Unit, net ton of 2,000 pounds.]

	Bituminous coal.									
	Carterville and Franklin, Ill.	Mount Olive, Ill.	Springfield, Ill.	Standard, Ill.	Clinton, Ill.	Eastern Kentucky.	Western Kentucky.	Georges Creek, Md.	Hocking, Ohio.	Pittsburgh, No. 8, Ohio.
Market	St. Louis	St. Louis	Chicago	St. Louis	Chicago	Louisville	Louisville	Boston	Columbus, Detroit.	Columbus, Detroit.
Base price	$1.16	$1.07	$1.26	$0.98	$1.10	$1.11	$0.89	$1.14	$1.16	$1.09
Year 1913	1.16	1.06	1.26	.98	1.11	1.12	.90	1.14	1.15	1.08
Quarters:										
First	1.16	1.06	1.28	.98	1.13	1.11	.91	1.14	1.16	1.08
Second	1.14	1.03	1.25	.95	1.12	1.08	.89	1.14	1.13	1.07
Third	1.16	1.06	1.24	.98	1.10	1.12	.87	1.14	1.15	1.07
Fourth	1.16	1.09	1.27	.99	1.10	1.15	.90	1.14	1.17	1.10
Months:										
January	1.17	1.09	1.30	1.00	1.13	1.16	.93	1.14	1.19	1.12
February	1.15	1.06	1.28	.98	1.12	1.11	.92	1.14	1.16	1.07
March	1.15	1.04	1.26	.97	1.13	1.08	.89	1.14	1.13	1.06
April	1.15	1.04	1.26	.95	1.13	1.11	.88	1.14	1.14	1.07
May	1.14	1.03	1.24	.95	1.12	1.06	.90	1.14	1.13	1.07
June	1.14	1.03	1.24	.96	1.12	1.08	.89	1.14	1.12	1.06
July	1.14	1.04	1.24	.96	1.11	1.10	.88	1.14	1.13	1.06
August	1.16	1.05	1.24	.98	1.10	1.12	.87	1.14	1.15	1.08
September	1.18	1.09	1.24	1.00	1.09	1.14	.88	1.14	1.16	1.08
October	1.18	1.09	1.29	.99	1.10	1.16	.90	1.14	1.16	1.10
November	1.16	1.11	1.28	.99	1.10	1.17	.91	1.14	1.20	1.12
December	1.15	1.08	1.25	.98	1.09	1.14	.91	1.14	1.16	1.08
Year 1914	1.15	1.05	1.25	.96	1.10	1.10	.87	1.16	1.16	1.10
Quarters:										
First	1.16	1.08	1.26	.98	1.10	1.08	.90	1.14	1.13	1.08
Second	1.16	1.04	1.25	.96	1.10	1.08	.88	1.16	1.17	1.11
Third	1.14	1.04	1.24	.95	1.10	1.11	.85	1.16	1.16	1.09
Fourth	1.13	1.06	1.23	.96	1.10	1.11	.85	1.16	1.16	1.11
Months:										
January	1.19	1.08	1.25	.97	1.10	1.12	.91	1.14	1.14	1.07
February	1.15	1.08	1.25	.98	1.09	1.07	.90	1.14	1.12	1.08
March	1.15	1.08	1.27	.99	1.10	1.06	.90	1.14	1.13	1.08
April	1.16	1.07	1.25	.96	1.10	1.08	.89	1.16	1.17	1.11
May	1.16	1.03	1.25	.98	1.10	1.09	.88	1.16	1.17	1.11
June	1.15	1.02	1.25	.96	1.10	1.08	.87	1.16	1.17	1.11

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July	1.14	1.00	1.08	1.26	.95	1.11	1.12	1.16	1.17	.86	1.16	1.07	1.10
August	1.14		1.08	1.26	.95	1.10	1.11	1.16	1.16	.83	1.16		1.09
September	1.15		1.08	1.23	.93	1.09	1.11	1.16	1.16	.83	1.16		1.10
October	1.13		1.08	1.26	.93	1.09	1.15	1.16	1.16	.85	1.16		1.12
November	1.12		1.08	1.26	.93	1.10	1.08	1.16	1.16	.85	1.16		1.12
December	1.13		1.08	1.26	.93	1.10	1.12	1.16		.85			
Year 1915	1.00	1.00	1.06	1.26	.94	1.09	1.06	1.12	1.15	.84	1.15	1.07	1.08
Quarters:													
First	1.13	1.06	1.06	1.26	.96	1.10	1.08	1.16	1.16	.86	1.16	1.11	1.10
Second	1.07	.93	.93	1.26	.93	1.10	1.04	1.16	1.14	.83	1.14	1.08	1.08
Third	1.06	.93	.93	1.26	.93	1.08	1.04	1.14	1.14	.83	1.14	1.08	1.08
Fourth	1.08	.93	.93	1.26	.94	1.10	1.09	1.16	1.12	.84	1.16	1.07	1.08
Months:													
January	1.14	1.06	1.06	1.26	.97	1.11	1.10	1.16	1.16	.85	1.16	1.12	1.12
February	1.13	1.05	1.05	1.26	.96	1.10	1.06	1.16	1.15	.86	1.16	1.13	1.10
March	1.13	1.05	1.05	1.26	.94	1.09	1.08	1.16	1.15	.87	1.16	1.10	1.10
April	1.08	.93	.93	1.26	.94	1.10	1.08	1.14	1.13	.83	1.14	1.08	1.08
May	1.07	.93	.93	1.26	.93	1.10	1.04	1.14	1.14	.83	1.14	1.08	1.08
June	1.06	.93	.93	1.25	.93	1.08	1.04	1.14	1.14	.83	1.14	1.08	1.08
July	1.06	.93	.93	1.26	.93	1.08	1.04	1.14	1.14	.83	1.14	1.10	1.08
August	1.04	.93	.93	1.25	.93	1.08	1.04	1.14	1.14	.83	1.14	1.08	1.08
September	1.06	.93	.93	1.26	.94	1.08	1.06	1.14	1.14	.83	1.14	1.08	1.08
October	1.06	.93	.93	1.26	.94	1.08	1.08	1.14	1.14	.85	1.14	1.07	1.08
November	1.06	.93	.93	1.26	.94	1.08	1.12	1.14	1.12	.85	1.21	1.07	1.08
December	1.06	.93	.97	1.27	.94	1.11	1.12	1.15	1.15	.85	1.21	1.08	1.09
Year 1916	1.18	1.03	1.03	1.32	1.02	1.19	1.13	1.27	1.19	.93	1.23	1.19	1.12
Quarters:													
First	1.10	.93	.93	1.26	.96	1.13	1.09	1.24	1.14	.85	1.24	1.06	1.06
Second	1.14	.93	.93	1.27	.97	1.14	1.05	1.26	1.20	.89	1.26	1.13	1.09
Third	1.15	.93	.93	1.27	.96	1.15	1.07	1.25	1.21	.91	1.25	1.13	1.10
Fourth	1.24	1.15	1.15	1.43	1.20	1.24	1.20	1.57	1.54	1.00	1.57	1.44	1.24
Months:													
January	1.09	.93	.93	1.26	.96	1.13	1.09	1.26	1.13	.86	1.26	1.06	1.07
February	1.11	.93	.93	1.26	.97	1.13	1.08	1.23	1.16	.85	1.23	1.07	1.08
March	1.09	.93	.93	1.26	.96	1.13	1.08	1.19	1.15	.85	1.19	1.06	1.08
April	1.14	.93	.93	1.26	.97	1.14	1.08	1.23	1.20	.89	1.23	1.12	1.12
May	1.14	.93	.93	1.26	.97	1.13	1.08	1.23	1.21	.89	1.23	1.13	1.12
June	1.14	.93	.93	1.26	.96	1.14	1.08	1.23	1.20	.88	1.23	1.13	1.12
July	1.14	.93	.93	1.26	.96	1.14	1.08	1.23	1.20	.88	1.23	1.13	1.12
August	1.15	.93	.93	1.26	1.00	1.15	1.08	1.23	1.20	.90	1.23	1.13	1.13
September	1.20	1.03	1.03	1.29	1.03	1.17	1.12	1.40	1.27	.94	1.40	1.25	1.18
October	1.36	1.20	1.20	1.54	1.22	1.20	1.33	1.68	1.67	1.15	1.68	1.46	1.36
November	1.46	1.26	1.26	1.62	1.31	1.45	1.38	1.68	1.67	1.13	1.68	1.48	1.38
December													
Year 1917	1.87	1.56	1.56	1.94	1.64	1.86	2.07	2.28	2.34	1.51	2.28	2.26	1.84
Quarters:													
First	1.42	1.22	1.22	1.83	1.21	1.45	1.36	1.70	1.61	1.11	1.62	1.64	1.47
Second	2.07	1.66	1.66	1.96	1.74	2.06	2.61	2.63	2.64	1.62	2.66	2.70	2.17
Third	2.03	1.66	1.66	1.94	1.78	2.00	2.26	2.45	2.41	1.66	2.45	2.47	2.16
Fourth	1.96	1.66	1.66	1.88	1.80	1.94	2.15	2.14	2.33	1.63	2.14	2.28	2.08

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Spot prices of bituminous coal and coke reduced to average realization base, f. o. b. mines, 1913–1918—Continued.

	Bituminous coal.									
	Carterville and Franklin, Ill.	Mount Olive, Ill.	Springfield, Ill.	Standard, Ill.	Clinton, Ill.	Eastern Kentucky.	Western Kentucky.	Georges Creek, Md.	Hocking, Ohio.	Pittsburgh No. 8, Ohio.
Market	St. Louis	St. Louis	Chicago	St. Louis	Chicago	Louisville	Louisville	Boston	Columbus, Detroit.	Columbus, Detroit.
Base price	$1.16	$1.07	$1.26	$0.98	$1.10	$1.11	$0.89	$1.14	$1.16	$1.09
Year 1917—Continued.										
Months:										
January	1.48	1.29	1.66	1.27	1.50	1.36	1.14	1.72	1.63	1.59
February	1.43	1.22	1.61	1.25	1.45	1.38	1.12	1.66	1.66	1.58
March	1.34	1.14	1.48	1.10	1.39	1.35	1.09	1.72	1.53	1.44
April	1.95	1.58	1.86	1.60	1.97	2.36	1.53	2.53	2.42	2.48
May	2.13	1.70	1.97	1.75	2.10	2.56	1.66	2.69	2.72	2.77
June	2.13	1.69	2.02	1.89	2.09	2.61	1.68	2.68	2.77	2.85
July	2.08	1.70	1.99	1.78	2.06	2.35	1.72	2.66	2.48	2.54
August	2.07	1.70	2.00	1.88	2.06	2.35	1.68	2.59	2.48	2.54
September	1.90	1.64	1.82	1.74	1.88	2.10	1.58	2.10	2.26	2.33
October	1.90	1.64	1.82	1.74	1.88	2.10	1.58	2.10	2.26	2.33
November	1.99	1.72	1.91	1.84	1.97	2.18	1.66	2.17	2.36	2.43
December	1.99	1.72	1.91	1.84	1.97	2.18	1.66	2.17	2.36	2.43
Year 1918	2.31	2.24	2.29	2.27	2.28	2.89	2.20	2.63	2.51	2.44
Quarters:										
First	1.99	1.72	1.91	1.84	1.97	2.18	1.66	2.21	2.36	2.43
Second	2.46	2.46	2.46	2.45	2.43	3.17	2.41	2.81	2.49	2.46
Third	2.39	2.39	2.39	2.39	2.37	3.11	2.35	2.75	2.61	2.44
Fourth	2.39	2.39	2.39	2.39	2.37	3.11	2.38	2.75	2.57	2.44
Months:										
January	1.99	1.72	1.91	1.84	1.97	2.18	1.66	2.17	2.36	2.43
February	1.99	1.72	1.91	1.84	1.97	2.18	1.66	2.23	2.36	2.43
March	1.99	1.72	1.91	1.84	1.97	2.18	1.66	2.24	2.36	2.43
April	2.49	2.49	2.49	2.49	2.45	3.21	2.44	2.85	2.52	2.50
May	2.49	2.49	2.49	2.49	2.47	3.21	2.44	2.85	2.52	2.50
June	2.39	2.39	2.39	2.39	2.37	3.11	2.34	2.75	2.42	2.40
July	2.39	2.39	2.39	2.39	2.37	3.11	2.34	2.75	2.62	2.44
August	2.39	2.39	2.39	2.39	2.37	3.11	2.34	2.75	2.62	2.44
September	2.39	2.39	2.39	2.39	2.37	3.11	2.38	2.75	2.57	2.44
October	2.39	2.39	2.39	2.39	2.37	3.11	2.38	2.75	2.57	2.44
November	2.39	2.39	2.39	2.39	2.37	3.11	2.38	2.75	2.57	2.44
December	2.39	2.39	2.39	2.39	2.37	3.11	2.38	2.75	2.57	2.44

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	Bituminous coal—Continued.						Coke.	
	Clearfield, Pa.	Pittsburgh, Pa.	Somerset and Cambria, Pa.	Kanawha, W. Va.	New River and Pocahontas, W. Va.	Weighted average, all districts.	Birmingham, Ala.	Connellsville, Pa.
Market	Boston	Pittsburgh	Boston	Columbus	Boston		Birmingham.	Connellsville.
Base price	$1.04	$1.12	$1.11	$0.94	$1.08	$1.17	$2.81	$2.23
Year 1913	1.04	1.13	1.12	.94	1.08	1.18	2.90	2.36
Quarters:								
First	1.08	1.13	1.15	.95	1.09	1.19	2.91	2.42
Second	1.02	1.12	1.10	.92	1.07	1.17	2.91	2.34
Third	1.03	1.12	1.12	.94	1.08	1.18	2.89	2.37
Fourth	1.04	1.14	1.11	.96	1.08	1.19	2.89	2.31
Months:								
January	1.16	1.14	1.23	.98	1.19	1.22	2.91	2.51
February	1.05	1.13	1.12	.94	1.05	1.18	2.91	2.38
March	1.04	1.13	1.11	.93	1.04	1.17	2.91	2.37
April	1.01	1.12	1.10	.92	1.06	1.17	2.91	2.34
May	1.02	1.13	1.09	.92	1.07	1.17	2.91	2.34
June	1.02	1.12	1.11	.92	1.08	1.17	2.91	2.34
July	1.03	1.12	1.12	.93	1.09	1.17	2.88	2.37
August	1.04	1.13	1.12	.96	1.08	1.18	2.87	2.38
September	1.03	1.12	1.12	.94	1.08	1.18	2.93	2.36
October	1.04	1.15	1.12	.94	1.08	1.19	2.91	2.33
November	1.04	1.15	1.11	.98	1.08	1.19	2.88	2.31
December	1.03	1.12	1.11	.96	1.08	1.18	2.87	2.30
Year 1914	1.05	1.08	1.11	.92	1.08	1.16	2.73	2.10
Quarters:								
First	1.02	1.12	1.11	.93	1.07	1.16	2.72	2.12
Second	1.07	1.09	1.11	.92	1.09	1.17	2.73	2.11
Third	1.06	1.07	1.12	.91	1.10	1.16	2.74	2.10
Fourth	1.06	1.06	1.10	.91	1.07	1.16	2.74	2.08
Months:								
January	1.08	1.13	1.11	.94	1.07	1.17	2.73	2.12
February	1.02	1.12	1.10	.92	1.07	1.16	2.72	2.12
March	1.02	1.12	1.11	.92	1.06	1.16	2.71	2.12
April	1.07	1.09	1.12	.92	1.10	1.17	2.73	2.12
May	1.07	1.09	1.11	.92	1.10	1.17	2.73	2.11
June	1.06	1.08	1.10	.91	1.08	1.16	2.74	2.10

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Spot prices of bituminous coal and coke reduced to average realization base f. o. b. mines, 1913–1918—Continued.

	Bituminous coal—Continued.						Coke.	
	Clearfield, Pa.	Pittsburgh, Pa.	Somerset and Cambria, Pa.	Kanawha, W. Va.	New River and Pocahontas, W. Va.	Weighted average, all districts.	Birmingham, Ala.	Connellsville, Pa.
Market	Boston	Pittsburgh	Boston	Columbus	Boston		Birmingham.	Connellsville.
Base price	$1.04	$1.12	$1.11	$0.94	$1.08	$1.17	$2.81	$2.23
Year 1914—Continued.								
Months—Continued.								
July	1.05	1.08	1.11	.91	1.07	1.16	2.74	2.10
August	1.06	1.08	1.12	.91	1.11	1.17	2.74	2.10
September	1.06	1.04	1.12	.91	1.11	1.16	2.74	2.09
October	1.06	1.05	1.12	.91	1.10	1.16	2.74	2.08
November	1.05	1.07	1.10	.90	1.06	1.16	2.73	2.08
December	1.05	1.06	1.09	.91	1.06	1.16	2.74	2.07
Year 1915	1.01	1.03	1.11	.87	1.05	1.13	2.78	2.06
Quarters:								
First	1.06	1.06	1.11	.90	1.08	1.16	2.78	2.03
Second	.97	1.01	1.09	.86	1.03	1.12	2.78	2.03
Third	.97	1.00	1.09	.86	1.04	1.11	2.77	2.04
Fourth	1.04	1.04	1.14	.87	1.05	1.14	2.79	2.13
Months:								
January	1.06	1.06	1.11	.91	1.07	1.16	2.78	2.03
February	1.06	1.07	1.11	.90	1.08	1.16	2.78	2.03
March	1.05	1.06	1.10	.90	1.09	1.15	2.78	2.03
April	.98	1.02	1.09	.86	1.01	1.12	2.78	2.03
May	.97	1.01	1.09	.86	1.04	1.12	2.78	2.03
June	.97	1.00	1.09	.86	1.05	1.11	2.77	2.04
July	.97	.99	1.09	.86	1.04	1.11	2.76	2.05
August	.97	1.00	1.09	.86	1.04	1.11	2.78	2.03
September	.98	1.00	1.09	.86	1.05	1.12	2.79	2.05
October	.98	1.01	1.10	.86	1.05	1.12	2.79	2.09
November	1.00	1.04	1.10	.87	1.05	1.13	2.79	2.12
December	1.14	1.06	1.24	.87	1.06	1.16	2.79	2.17
Year 1916	1.17	1.20	1.32	1.03	1.12	1.24	3.49	2.71
Quarters:								
First	1.17	1.12	1.26	.89	1.05	1.17	3.44	2.67
Second	1.09	1.12	1.23	.97	1.03	1.20	3.48	2.61
Third	1.09	1.12	1.23	1.01	1.07	1.21	3.49	2.64
Fourth	1.32	1.41	1.52	1.27	1.34	1.40	3.54	2.91
Months:								
January	1.29	1.16	1.38	.89	1.06	1.19	3.44	2.65
February	1.15	1.12	1.26	.90	1.05	1.17	3.44	2.68

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March	1.06	1.06	1.16	.89	1.05	1.15	3.46	2.69
April	1.11	1.10	1.25	.97	1.03	1.20	3.46	2.61
May	1.09	1.11	1.24	.97	1.03	1.20	3.46	2.60
June	1.07	1.16	1.22	.97	1.03	1.20	3.46	2.62
July	1.08	1.11	1.22	.98	1.03	1.20	3.49	2.64
August	1.08	1.12	1.28	1.00	1.06	1.20	3.49	2.64
September	1.11	1.14	1.26	1.04	1.12	1.23	3.49	2.65
October	1.22	1.25	1.37	1.16	1.19	1.29	3.49	2.78
November	1.38	1.51	1.54	1.33	1.38	1.45	3.52	2.93
December	1.37	1.48	1.66	1.31	1.44	1.46	3.61	3.03
Year 1917	2.30	2.18	2.36	2.11	2.09	2.07	5.80	4.86
Quarters:								
First	1.49	1.49	1.65	1.31	1.39	1.47	5.66	4.88
Second	2.85	2.65	2.89	2.55	2.56	2.40	5.83	4.84
Third	2.50	2.35	2.53	2.34	2.27	2.24	5.91	5.03
Fourth	2.35	2.25	2.36	2.24	2.12	2.17	5.79	4.89
Months:								
January	1.47	1.48	1.64	1.27	1.40	1.48	5.65	4.82
February	1.46	1.54	1.61	1.35	1.39	1.48	5.66	4.88
March	1.54	1.46	1.69	1.32	1.39	1.45	5.69	4.88
April	2.77	2.48	2.82	2.42	2.41	2.30	5.77	4.77
May	2.91	2.70	2.95	2.61	2.62	2.44	5.88	4.79
June	2.87	2.77	2.91	2.61	2.66	2.46	5.85	4.97
July	2.58	2.43	2.60	2.45	2.33	2.30	5.88	5.04
August	2.64	2.43	2.67	2.38	2.42	2.31	5.92	5.09
September	2.27	2.18	2.31	2.18	2.07	2.12	5.92	4.96
October	2.27	2.18	2.31	2.18	2.07	2.12	5.88	4.89
November	2.39	2.28	2.39	2.27	2.15	2.19	5.74	4.69
December	2.39	2.28	2.39	2.27	2.15	2.19	5.74	4.69
Year 1918	2.84	2.36	2.84	2.53	2.42	2.56	7.08	6.03
Quarters:								
First	2.44	2.28	2.45	2.27	2.15	2.20	6.65	6.03
Second	3.01	2.42	3.01	2.61	2.53	2.71	7.03	6.03
Third	2.95	2.36	2.95	2.63	2.49	2.67	7.19	6.03
Fourth	2.95	2.36	2.95	2.63	2.49	2.67	7.46	6.03
Months:								
January	2.39	2.28	2.39	2.27	2.15	2.19	6.06	6.03
February	2.44	2.28	2.45	2.27	2.15	2.20	6.92	6.03
March	2.50	2.28	2.51	2.27	2.15	2.21	6.97	6.03
April	3.05	2.46	3.05	2.48	2.51	2.71	7.03	6.03
May	3.05	2.46	3.05	2.73	2.59	2.75	7.03	6.03
June	2.95	2.36	2.95	2.63	2.49	2.66	7.03	6.03
July	2.95	2.36	2.95	2.63	2.49	2.66	7.05	6.03
August	2.95	2.36	2.95	2.63	2.49	2.67	7.09	6.03
September	2.95	2.36	2.95	2.63	2.49	2.67	7.43	6.03
October	2.95	2.36	2.95	2.63	2.49	2.67	7.46	6.03
November	2.95	2.36	2.95	2.63	2.49	2.67	7.46	6.03
December	2.95	2.36	2.95	2.63	2.49	2.67	7.46	6.03

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Relative prices of bituminous coal and coke, based on spot prices reduced to average realization base, f. o. b. mines, 1913–1918.

[Unit, net ton of 2,000 pounds.]

	Bituminous coal.									
	Carterville and Franklin, Ill.	Mount Olive, Ill.	Springfield, Ill.	Standard, Ill.	Clinton, Ind.	Eastern Kentucky.	Western Kentucky.	Georges Creek, Md.	Hocking, Ohio.	Pittsburgh No. 8, Ohio.
Market	St. Louis	St. Louis	Chicago	St. Louis	Chicago	Louisville	Louisville	Boston	Columbus, Detroit.	Columbus, Detroit.
Base price	$1.16	$1.07	$1.26	$0.98	$1.10	$1.11	$0.89	$1.14	$1.16	$1.09
Year 1913	100	99	100	100	101	101	101	100	100	99
Quarters:										
First	100	99	102	100	103	100	102	100	100	99
Second	98	96	100	97	102	97	100	100	98	98
Third	100	99	99	100	100	101	98	100	100	98
Fourth	100	102	101	101	100	104	101	100	101	101
Months:										
January	101	102	104	102	103	104	103	100	103	103
February	99	99	102	100	102	100	103	100	100	98
March	99	97	100	99	103	97	100	100	98	97
April	99	97	100	97	103	100	99	100	99	98
May	98	96	99	97	102	95	101	100	98	98
June	98	96	99	98	102	97	100	100	97	97
July	98	97	99	98	101	99	99	100	98	97
August	100	98	99	100	100	101	98	100	99	99
September	102	102	99	102	99	103	99	100	100	99
October	102	102	103	101	100	104	101	100	100	101
November	100	104	102	101	100	105	102	100	104	103
December	99	101	100	100	99	103	102	100	100	99
Year 1914	99	98	100	98	100	99	97	102	100	101
Quarters:										
First	100	101	100	100	100	97	101	100	98	99
Second	100	97	100	98	100	97	99	102	101	102
Third	98	97	99	97	100	100	95	102	100	100
Fourth	97	99	100	98	100	100	95	102	100	102
Months:										
January	102	101	100	99	100	101	102	100	99	98
February	99	101	100	100	99	96	101	100	97	99
March	99	101	101	101	100	95	101	100	98	99
April	99	100	100	98	100	97	100	102	101	102
May	99	96	100	100	100	98	99	102	101	102
June	99	95	100	98	100	97	98	102	101	102

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Relative prices of bituminous coal and coke, based on spot prices reduced to average realization base, f. o. b. mines, 1913–1918—Continued.

	Bituminous coal.									
	Carterville and Franklin, Ill.	Mount Olive, Ill.	Springfield, Ill.	Standard, Ill.	Clinton, Ind.	Eastern Kentucky.	Western Kentucky.	Georges Creek, Md.	Hocking, Ohio.	Pittsburgh No. 8, Ohio.
Market	St. Louis	St. Louis	Chicago	St. Louis	Chicago	Louisville	Louisville	Boston	Columbus, Detroit.	Columbus, Detroit.
Base price	$1.16	$1.07	$1.26	$0.98	$1.10	$1.11	$0.89	$1.14	$1.16	$1.09
Year 1917—Continued.										
Months:										
January	127	119	132	130	140	122	128	151	141	146
February	123	114	128	128	135	124	126	146	144	145
March	115	107	118	112	129	122	122	151	132	132
April	168	148	148	164	179	212	172	222	210	228
May	183	159	157	179	191	230	186	236	235	254
June	183	158	161	193	190	235	188	235	240	261
July	179	159	159	182	188	212	193	233	215	233
August	179	159	159	187	188	212	188	227	215	233
September	164	154	145	178	171	189	177	184	196	214
October	164	154	145	178	171	189	177	184	196	214
November	171	161	152	188	179	196	186	190	204	223
December	171	161	152	188	179	196	186	190	204	223
Year 1918	198	210	182	232	208	260	247	231	217	224
Quarters:										
First	171	161	152	188	179	196	186	194	204	223
Second	212	230	196	250	221	285	270	246	216	226
Third	206	224	190	244	216	280	263	241	226	224
Fourth	206	224	190	244	216	280	267	241	223	224
Months:										
January	171	161	152	188	179	196	186	190	204	223
February	171	161	152	188	179	196	186	196	204	223
March	171	161	152	188	179	196	186	196	204	223
April	214	233	198	254	223	289	274	250	218	229
May	214	233	198	254	225	289	274	250	218	229
June	206	224	190	244	216	280	262	241	210	202
July	206	224	190	244	216	280	262	241	227	224
August	206	224	190	244	216	280	262	241	227	224
September	206	224	190	244	216	280	267	241	223	224
October	206	224	190	244	216	280	267	241	223	224
November	206	224	190	244	216	280	267	241	223	224
December	206	224	190	244	216	280	267	241	223	224

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	Bituminous coal—Continued.						Coke.	
	Clearfield, Pa.	Pittsburgh, Pa.	Somerset and Cambria, Pa.	Kanawha, W. Va.	New River and Pocahontas, W. Va.	Weighted average of all districts.	Birmingham, Ala.	Connellsville, Pa.
Market	Boston	Pittsburgh	Boston	Columbus	Boston		Birmingham	Connellsville
Base price	$1.04	$1.12	$1.11	$0.94	$1.08	$1.17	$2.81	$2.23
Year 1913	100	101	101	100	100	101	103	106
Quarters:								
First	104	101	108	101	101	101	104	109
Second	98	100	99	98	99	100	104	105
Third	99	100	101	100	100	101	103	106
Fourth	100	102	100	103	100	101	103	104
Months:								
January	112	102	110	105	110	104	104	113
February	101	101	101	100	97	101	104	107
March	100	101	100	99	96	100	104	106
April	97	100	99	98	98	100	104	105
May	98	101	98	98	99	100	104	105
June	98	100	100	98	100	100	104	105
July	99	100	101	99	101	100	102	106
August	100	101	101	102	100	101	102	107
September	99	100	101	100	100	101	104	106
October	100	103	101	100	100	101	104	104
November	100	103	100	104	100	101	102	104
December	99	100	100	102	100	101	102	103
Year 1914	101	97	100	98	100	99	97	94
Quarters—								
First	98	100	100	99	99	99	97	95
Second	103	98	100	98	101	100	97	95
Third	102	96	101	97	102	99	98	94
Fourth	102	95	99	97	99	99	98	93
Months—								
January	99	101	100	100	99	100	97	95
February	98	100	99	98	99	99	97	95
March	98	100	100	98	98	99	96	95
April	103	98	101	98	102	100	97	95
May	103	98	100	98	102	100	97	95
June	102	97	99	97	100	99	98	94
July	101	97	100	97	99	99	98	94
August	102	97	101	97	103	100	98	94
September	102	98	101	97	103	99	98	94

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Relative prices of bituminous coal and coke based on spot prices reduced to average realization base, f. o. b. mines, 1913–1918—Continued.

	Bituminous coal—Continued.						Coke.	
	Clearfield, Pa.	Pittsburgh, Pa.	Somerset and Cambria, Pa.	Kanawha, W. Va.	New River and Pocahontas, W. Va.	Weighted average of all districts.	Birmingham, Ala.	Connellsville, Pa.
Market	Boston	Pittsburgh	Boston	Columbus	Boston		Birmingham	Connellsville
Base price	$1.04	$1.12	$1.11	$0.94	$1.08	$1.17	$2.81	$2.23
Year 1914—Continued.								
Months—Continued.								
October	102	94	101	97	102	99	98	93
November	101	96	99	96	98	99	97	93
December	101	95	98	97	98	99	98	93
Year 1915	97	92	100	93	97	96	99	92
Quarters:								
First	102	95	100	96	100	99	99	91
Second	93	90	98	92	95	95	99	91
Third	93	89	98	92	96	95	99	91
Fourth	100	93	102	98	97	97	99	96
Months:								
January	102	95	100	97	99	99	99	91
February	102	96	100	96	100	99	99	91
March	101	95	99	96	101	98	99	91
April	94	91	98	92	93	95	99	91
May	93	90	98	92	96	95	99	91
June	93	89	98	92	97	95	99	91
July	93	88	98	92	96	95	98	92
August	93	89	98	92	96	95	99	91
September	94	89	98	92	97	95	99	92
October	94	90	99	92	97	95	99	94
November	96	93	99	93	97	96	99	95
December	110	95	111	93	98	99	99	97
Year 1916	112	107	119	110	104	106	124	122
Quarters:								
First	112	100	118	95	97	100	122	120
Second	105	100	111	104	95	102	124	117
Third	105	100	111	108	99	102	124	118
Fourth	127	126	137	136	124	119	126	130
Months:								
January	124	104	124	95	98	101	122	119
February	111	100	113	96	97	100	122	120
March	102	97	104	95	97	98	123	121

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April	107	98	112	104	96	102	124	117
May	105	99	111	104	96	102	124	117
June	103	104	110	104	96	102	124	117
July	104	99	110	105	95	102	124	118
August	104	100	110	107	98	102	124	118
September	107	102	118	111	104	105	124	119
October	117	112	128	124	110	110	124	125
November	133	135	138	110	128	124	125	131
December	132	132	149	140	133	124	128	136
Year 1917	221	195	212	225	193	176	206	218
Quarters:								
First	143	133	148	140	129	125	201	219
Second	274	237	260	272	237	205	207	217
Third	240	210	227	250	210	191	210	226
Fourth	226	201	212	239	196	185	206	210
Months:								
January	141	132	147	136	130	126	201	218
February	140	138	145	144	129	126	201	219
March	148	132	152	141	129	124	203	219
April	266	222	253	258	223	196	205	214
May	280	242	265	279	242	208	209	215
June	276	248	262	279	246	210	208	223
July	248	217	234	262	216	196	209	226
August	254	217	240	254	224	196	211	228
September	218	195	208	233	191	181	211	222
October	218	195	208	233	191	181	209	210
November	230	204	215	242	199	187	204	210
December	230	204	215	242	199	187	204	210
Year 1918	273	211	255	270	224	218	252	270
Quarters:								
First	235	204	220	242	199	188	237	270
Second	289	216	271	279	234	231	250	270
Third	284	211	265	281	230	228	256	270
Fourth	284	211	265	281	230	228	266	270
Months:								
January	230	204	215	242	199	187	216	270
February	235	204	220	242	199	188	246	270
March	240	204	226	242	199	188	248	270
April	293	220	274	265	232	231	250	270
May	293	220	274	292	240	234	250	270
June	284	211	265	281	230	227	250	270
July	284	211	265	281	230	227	251	270
August	284	211	265	281	230	228	252	270
September	284	211	265	281	230	228	264	270
October	284	211	265	281	230	228	266	270
November	284	211	265	281	230	228	266	270
December	284	211	265	281	230	228	266	270

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Relative prices of bituminous coal and coke, spot prices as base, f. o. b. mines, 1913–1918.

[Unit, net ton of 2,000 pounds.]

	Bituminous coal.									
	Carterville and Franklin, Ill.	Mount Olive, Ill.	Springfield, Ill.	Standard, Ill.	Clinton, Ind.	Eastern Kentucky.	Western Kentucky.	Georges Creek, Md.	Hocking, Ohio.	Pittsburgh No. 8, Ohio.
Market	St. Louis	St. Louis	Chicago	St. Louis	Chicago	Louisville	Louisville	Boston	Columbus, Detroit.	Columbus, Detroit.
Base price	$1.16	$1.24	$1.06	$0.91	$1.13	$1.52	$0.98	$1.54	$1.19	$1.12
Year 1913	98	97	100	99	105	105	102	100	102	100
Quarters:										
First	98	98	107	101	110	104	108	100	106	101
Second	94	86	96	97	108	92	99	100	95	96
Third	100	95	95	100	100	106	93	100	100	97
Fourth	101	108	104	100	99	118	107	100	109	107
Months:										
January	103	108	112	108	110	120	115	100	116	113
February	96	96	106	100	109	102	110	100	104	98
March	96	90	101	96	110	90	100	100	96	93
April	96	89	101	99	111	102	95	100	97	97
May	94	84	93	99	107	85	103	100	96	96
June	93	83	94	91	106	89	98	100	92	94
July	94	86	94	91	104	99	94	100	96	92
August	99	92	95	101	100	106	90	100	101	99
September	106	108	96	107	98	113	94	100	103	100
October	107	106	110	104	101	119	102	100	105	106
November	101	114	106	104	101	125	109	100	118	115
December	94	104	98	92	96	111	109	100	105	100
Year 1914	96	98	100	98	99	90	92	100	94	97
Quarters:										
First	102	104	99	99	99	92	104	100	95	99
Second	98	93	102	101	100	83	95	100	96	98
Third	94	93	98	93	98	92	86	100	94	92
Fourth	88	102	105	97	98	94	84	100	91	100
Months:										
January	110	104	98	95	99	106	106	100	99	98
February	96	104	97	100	98	87	104	100	91	99
March	98	103	102	103	102	84	103	100	96	99
April	100	103	101	100	100	81	100	100	96	99
May	99	91	103	104	101	87	95	100	96	97
June	96	85	101	98	99	82	91	100	97	97
July	93	87	100	92	101	93	87	100	96	95

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August	93	94	98	92	99	91	86	100	92	92
September	96	99	94	96	93	92	84	100	93	93
October	88	102	103	95	96	104	83	100	90	103
November	86	102	105	97	98	82	85	100	92	102
December	89	101	106	100	101	98	85	100	92	98
Year 1915	94	93	105	97	96	88	94	102	92	96
Quarters:										
First	90	99	108	100	99	83	89	100	91	101
Second	94	91	103	96	96	83	92	100	90	91
Third	94	93	104	95	92	84	94	100	91	93
Fourth	98	91	110	99	97	104	102	108	97	99
Months:										
January	91	100	105	102	101	90	84	100	94	103
February	90	100	101	99	99	83	89	100	91	105
March	89	97	102	99	97	77	94	100	89	95
April	91	94	103	99	98	80	95	100	90	94
May	94	91	102	96	98	85	93	100	90	88
June	96	86	104	91	93	83	88	100	91	90
July	92	89	102	92	91	81	91	100	91	89
August	92	95	104	93	91	82	95	100	90	94
September	97	95	107	98	93	90	95	100	91	95
October	96	95	103	97	94	98	95	100	93	98
November	99	95	110	99	94	102	105	100	98	97
December	98	84	112	100	102	113	106	126	101	100
Year 1916	131	119	148	138	138	131	136	156	158	162
Quarters:										
First	104	93	114	103	107	100	105	139	103	96
Second	103	94	113	98	103	89	93	103	102	102
Third	103	96	122	107	116	104	109	99	109	109
Fourth	208	193	241	241	224	230	237	285	314	340
Months:										
January	101	88	113	109	105	100	103	162	103	96
February	103	95	115	112	109	102	106	134	105	97
March	103	95	114	103	107	97	102	121	101	95
April	103	95	113	103	103	92	95	110	100	102
May	102	94	112	95	106	88	93	100	104	102
June	103	92	114	97	109	88	90	99	104	103
July	103	91	115	100	109	91	88	97	102	103
August	109	94	117	103	114	93	107	95	101	103
September	112	104	134	118	125	127	134	105	122	128
October	134	119	134	153	129	172	172	184	211	228
November	220	210	270	253	257	243	276	353	397	425
December	271	248	318	315	287	275	265	319	335	366
Year 1917	231	193	251	234	246	224	243	280	277	299
Quarters:										
First	252	220	294	246	288	265	257	359	360	405
Second	248	175	248	191	257	279	232	342	317	338
Third	225	186	242	244	232	194	252	269	230	240
Fourth	201	189	216	256	204	156	234	149	199	211

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Relative prices of bituminous coal and coke, spot prices as base, f. o. b. mines, 1913–1918—Continued.

	Bituminous coal.									
	Carterville and Franklin, Ill.	Mount Olive, Ill.	Springfield, Ill.	Standard, Ill.	Clinton, Ind.	Eastern Kentucky.	Western Kentucky.	Georges Creek, Md.	Hocking, Ohio.	Pittsburgh No. 8, Ohio.
Market	St. Louis	St. Louis	Chicago	St. Louis	Chicago	Louisville	Louisville	Boston	Columbus, Detroit.	Columbus, Detroit.
Base price	$1.16	$1.24	$1.06	$0.91	$1.13	$1.52	$0.98	$1.54	$1.19	$1.12
Year 1917—Continued.										
Months:										
January	284	263	336	288	317	265	271	371	376	442
February	257	221	308	273	291	274	261	337	394	438
March	213	176	240	178	256	257	239	368	311	335
April	197	142	202	144	220	228	176	301	236	248
May	275	194	258	240	277	298	252	366	352	374
June	272	188	283	190	276	311	268	360	362	392
July	252	197	267	242	261	223	287	355	258	269
August	248	198	272	267	260	223	263	225	258	269
September	174	163	188	222	177	136	204	130	174	184
October	174	163	188	222	177	136	204	130	174	184
November	214	201	230	273	217	166	250	159	211	224
December	214	201	230	273	217	166	250	159	211	224
Year 1918	209	197	226	267	213	197	246	179	213	221
Quarters:										
First	214	201	230	273	217	166	250	177	211	224
Second	212	199	228	270	216	210	247	183	209	222
Third	206	193	222	263	210	205	240	179	218	219
Fourth	206	193	222	263	210	205	243	179	215	219
Months:										
January	214	201	230	273	217	166	250	159	211	224
February	214	201	230	273	217	166	250	185	211	224
March	214	201	230	273	217	166	250	185	211	224
April	214	201	231	274	217	212	250	185	211	224
May	214	201	231	274	219	212	250	185	211	224
June	206	193	222	263	210	205	239	179	208	215
July	206	193	222	263	210	205	239	179	220	219
August	206	193	222	263	210	205	239	179	220	219
September	206	193	222	263	210	205	243	179	215	219
October	206	193	222	263	210	205	243	179	215	219
November	206	193	222	263	210	205	243	179	215	219
December	206	193	222	263	210	205	243	179	215	219

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Relative prices of bituminous coal and coke, spot prices as base, f. o. b. mines, 1913–1918—Continued.

[Unit, net ton of 2,000 pounds.]

	Bituminous coal—Continued.							Coke.	
	Clearfield, Pa.	Pittsburgh, Pa.	Somerset, Cambria, Pa.	Kanawha, W. Va.	New River and Pocahontas, W. Va.	Alabama.	Weighted average of all districts.	Birmingham, Ala.	Connellsville, Pa.
Market	Boston	Pittsburgh	Boston	Columbus	Boston	Birmingham		Birmingham,	Connellsville.
Base price	$1.12	$1.26	$1.30	$1.16	$1.30	$1.33	$1.27	$2.90	$2.01
Year 1913	106	101	104	102	103	104	102	110	118
Quarters:									
First	122	102	117	105	108	102	106	115	147
Second	95	99	96	98	97	102	97	114	107
Third	103	99	103	100	105	101	100	107	121
Fourth	104	105	101	110	102	111	104	105	95
Months:									
January	152	105	145	119	142	102	116	115	194
February	110	100	104	101	93	102	102	115	127
March	104	100	100	95	89	102	99	115	121
April	92	99	94	95	94	102	98	113	109
May	95	101	93	93	99	102	97	115	107
June	99	96	99	91	100	101	97	115	106
July	100	97	103	97	107	101	99	103	123
August	106	101	104	100	105	101	101	100	125
September	102	99	103	102	103	101	102	119	115
October	107	106	104	103	105	102	105	112	105
November	103	106	101	118	101	110	107	104	92
December	101	98	98	110	100	121	101	98	88
Year 1914	95	93	97	93	94	95	96	96	87
Quarters:									
First	98	99	98	97	97	95	99	91	94
Second	96	97	97	94	96	94	97	97	90
Third	93	89	98	91	96	94	95	99	85
Fourth	92	87	94	89	88	95	95	98	77
Months:									
January	100	100	98	102	98	95	100	95	98
February	97	99	97	94	98	95	98	90	98
March	97	99	99	95	96	94	98	89	96
April	97	97	100	94	97	94	98	96	94
May	97	99	98	94	97	94	98	96	89
June	98	95	95	93	92	94	95	98	88
July	91	95	95	93	86	94	94	98	88

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Relative prices of bituminous coal and coke, spot prices as base, f. o. b. mines, 1913–1918—Continued.

	Bituminous coal—Continued.							Coke.	
	Clearfield, Pa.	Pittsburgh, Pa.	Somerset, Cambria, Pa.	Kanawha, W. Va.	New River and Pocahontas, W. Va.	Alabama.	Weighted average of all districts.	Birmingham, Ala.	Connellsville, Pa.
Market	Boston	Pittsburgh	Boston	Columbus	Boston	Birmingham		Birmingham,	Connellsville.
Base price	$1.12	$1.26	$1.30	$1.16	$1.30	$1.33	$1.27	$2.90	$2.01
Year 1914—Continued.									
Months—Continued.									
August	93	92	99	90	100	94	95	100	86
September	95	80	100	90	102	94	94	99	83
October	94	84	99	91	97	94	95	98	80
November	92	91	93	88	84	94	94	96	76
December	92	87	91	90	84	98	95	99	75
Year 1915	98	83	101	89	94	94	94	98	87
Quarters:									
First	94	88	96	89	90	94	93	99	76
Second	90	79	96	88	91	94	91	97	77
Third	90	75	95	88	94	94	91	97	80
Fourth	120	88	118	92	98	94	99	100	116
Months:									
January	95	89	97	92	87	94	95	99	76
February	95	90	97	89	90	94	94	99	76
March	92	87	95	88	93	94	92	98	76
April	91	84	95	88	86	94	91	99	76
May	89	78	95	88	93	94	91	96	76
June	89	76	97	88	95	94	90	93	78
July									
August	89	74	95	88	90	94	89	91	82
September	89	75	95	88	93	94	90	96	76
October	91	76	96	88	97	94	93	100	81
November	93	79	98	89	97	94	94	100	102
December	101	89	100	93	97	94	97	100	115
Year 1916	166	94	157	95	99	94	107	100	132
Quarters:	176	165	178	147	163	123	140	120	163
First	175	114	168	101	99	98	114	105	121
Second	117	112	118	82	97	103	103	117	141
Third	118	112	118	110	129	111	110	119	335
Fourth	294	320	308	296	329	180	235	137	190
Months:									
January	230	126	215	100	100	94	121	104	147
February	168	115	164	103	99	99	114	101	168

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March	126	101	126	99	98	99	105	111	179
April	139	98	139	82	97	101	104	116	192
May	116	103	119	82	97	103	102	116	116
June	103	137	107	82	96	104	105	118	126
July	103	107	107	90	100	107	102	119	127
August	113	108	114	104	118	110	106	119	140
September	134	122	134	137	168	117	128	120	147
October	218	204	208	217	215	132	166	119	242
November	335	392	320	339	366	175	265	130	344
December	330	366	396	331	406	233	278	161	418
Year 1917	332	285	300	275	291	239	243	285	460
Quarters:									
First	422	382	390	328	374	226	280	181	479
Second	426	347	389	328	368	265	276	248	440
Third	273	236	243	241	243	224	214	280	623
Fourth	204	184	178	200	181	201	192	229	300
Months:									
January	411	373	383	297	330	226	294	173	474
February	396	415	364	357	370	226	296	179	481
March	459	358	423	331	373	226	278	190	481
April	392	280	360	276	304	245	236	223	376
May	456	367	414	357	392	271	293	267	389
June	435	396	395	353	410	279	297	255	561
July	308	269	273	267	267	257	235	268	636
August	332	269	302	269	304	257	239	285	677
September	178	160	154	174	158	158	167	285	555
October	178	160	154	174	158	179	170	269	299
November	218	196	189	213	192	212	203	309	309
December	218	196	189	213	192	212	204	309	300
Year 1918	260	191	225	223	192	201	211	294	300
Quarters:									
First	244	196	212	213	192	190	208	229	300
Second	268	194	233	224	194	192	214	242	300
Third	262	188	228	226	191	207	211	248	300
Fourth	262	188	228	226	191	212	211	257	300
Months:									
January	218	196	189	213	192	212	205	209	300
February	244	196	212	213	192	179	208	239	300
March	271	196	236	213	192	179	211	240	300
April	271	196	236	213	192	179	214	242	300
May	271	196	236	235	199	194	217	242	300
June	262	188	228	226	191	205	210	242	300
July	262	188	228	226	191	205	210	243	300
August	262	188	228	226	191	205	211	245	300
September	262	188	228	226	191	212	211	256	300
October	262	188	228	226	191	212	211	257	300
November	262	188	228	226	191	212	211	257	300
December	262	188	228	226	191	212	211	257	300

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Spot prices of bituminous coal and coke f. o. b. mines, 1913–1918.

[Unit, net ton of 2,000 pounds.]

	Bituminous coal.									
	Carterville and Franklin, Ill.	Mount Olive, Ill.	Springfield, Ill.	Standard, Ill.	Clinton, Ind.	Eastern Kentucky.	Western Kentucky.	Georges Creek, Md.	Hocking, Ohio.	Pittsburgh No. 8, Ohio.
Market	St. Louis	St. Louis	Chicago	St. Louis	Chicago	Louisville	Louisville	Boston	Columbus, Detroit.	Columbus, Detroit.
Base price	$1.16	$1.24	$1.08	$0.91	$1.13	$1.52	$0.98	$1.54	$1.19	$1.12
Year 1913	1.14	1.20	1.06	.90	1.18	1.59	1.00	1.54	1.22	1.12
Quarters:										
First	1.14	1.21	1.15	.92	1.24	1.56	1.06	1.54	1.26	1.13
Second	1.09	1.06	1.03	.88	1.22	1.39	.97	1.54	1.13	1.07
Third	1.16	1.18	1.02	.91	1.13	1.61	.91	1.54	1.19	1.06
Fourth	1.17	1.34	1.12	.91	1.12	1.79	1.05	1.54	1.30	1.19
Months:										
January	1.19	1.33	1.21	.98	1.24	1.82	1.12	1.54	1.39	1.26
February	1.12	1.19	1.14	.91	1.23	1.54	1.08	1.54	1.24	1.09
March	1.12	1.11	1.09	.87	1.24	1.37	.98	1.54	1.14	1.04
April	1.11	1.10	1.09	.90	1.25	1.54	.93	1.54	1.16	1.08
May	1.09	1.04	1.00	.90	1.21	1.29	1.01	1.54	1.14	1.07
June	1.08	1.03	1.01	.88	1.20	1.35	.96	1.54	1.10	1.05
July	1.09	1.06	1.01	.88	1.17	1.50	.92	1.54	1.14	1.08
August	1.15	1.14	1.02	.92	1.13	1.60	.88	1.54	1.20	1.10
September	1.23	1.33	1.03	.97	1.10	1.72	.92	1.54	1.23	1.12
October	1.24	1.34	1.18	.95	1.14	1.80	1.00	1.54	1.25	1.18
November	1.17	1.41	1.14	.95	1.14	1.89	1.07	1.54	1.41	1.28
December	1.09	1.28	1.05	.84	1.08	1.89	1.07	1.54	1.25	1.12
Year 1914	1.11	1.21	1.08	.89	1.12	1.37	.90	1.54	1.12	1.08
Quarters:										
First	1.18	1.28	1.07	.90	1.12	1.40	1.02	1.54	1.13	1.10
Second	1.14	1.15	1.10	.92	1.13	1.26	.93	1.54	1.15	1.09
Third	1.09	1.15	1.05	.85	1.10	1.40	.84	1.54	1.12	1.03
Fourth	1.02	1.26	1.13	.88	1.11	1.43	.82	1.54	1.09	1.12
Months:										
January	1.28	1.28	1.06	.86	1.12	1.61	1.04	1.54	1.18	1.09
February	1.12	1.28	1.04	.91	1.10	1.32	1.02	1.54	1.08	1.10
March	1.14	1.27	1.10	.94	1.15	1.27	1.01	1.54	1.14	1.10
April	1.16	1.27	1.09	.91	1.13	1.23	.98	1.54	1.14	1.10
May	1.15	1.13	1.11	.95	1.14	1.32	.98	1.54	1.14	1.08
June	1.11	1.05	1.09	.89	1.12	1.24	.89	1.54	1.16	1.08

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July	1.08	1.08	1.08	.84	1.14	1.41	.85	1.54	1.14	1.06
August	1.08	1.16	1.05	.84	1.12	1.38	.84	1.54	1.12	1.02
September	1.11	1.22	1.01	.87	1.05	1.40	.82	1.54	1.11	1.02
October	1.02	1.26	1.11	.86	1.08	1.58	.81	1.54	1.10	1.07
November	1.00	1.26	1.13	.88	1.11	1.24	.83	1.54	1.07	1.14
December	1.03	1.25	1.14	.91	1.14	1.48	.83	1.54	1.10	1.14
Year 1915	1.09	1.15	1.13	.88	1.08	1.34	.92	1.57	1.10	1.07
Quarters:										
First	1.04	1.22	1.11	.91	1.12	1.26	.87	1.54	1.09	1.13
Second	1.09	1.12	1.11	.87	1.08	1.26	.90	1.54	1.07	1.01
Third	1.09	1.15	1.12	.86	1.04	1.28	.92	1.54	1.08	1.03
Fourth	1.14	1.13	1.18	.90	1.09	1.58	1.00	1.67	1.16	1.10
Months:										
January	1.06	1.23	1.13	.93	1.14	1.36	.82	1.54	1.12	1.15
February	1.04	1.23	1.09	.90	1.12	1.26	.87	1.54	1.09	1.17
March	1.03	1.20	1.10	.90	1.09	1.16	.92	1.54	1.06	1.06
April	1.06	1.16	1.11	.90	1.10	1.22	.93	1.54	1.07	1.05
May	1.09	1.13	1.10	.87	1.10	1.29	.91	1.54	1.07	.98
June	1.11	1.06	1.12	.83	1.05	1.26	.86	1.54	1.08	1.00
July	1.07	1.10	1.10	.84	1.03	1.23	.89	1.54	1.09	.99
August	1.07	1.17	1.12	.85	1.03	1.24	.93	1.54	1.07	1.05
September	1.13	1.17	1.15	.89	1.05	1.36	.93	1.54	1.08	1.06
October	1.12	1.17	1.16	.88	1.06	1.49	.93	1.54	1.11	1.09
November	1.15	1.17	1.18	.90	1.06	1.55	1.03	1.54	1.17	1.08
December	1.14	1.04	1.21	.91	1.15	1.71	1.04	1.94	1.20	1.12
Year 1916	1.52	1.47	1.59	1.26	1.56	1.98	1.33	2.41	1.88	1.81
Quarters:										
First	1.21	1.15	1.38	.96	1.21	1.51	1.03	2.14	1.23	1.07
Second	1.19	1.16	1.22	.89	1.22	1.35	.91	1.69	1.22	1.14
Third	1.25	1.19	1.31	.97	1.31	1.57	1.07	1.53	1.30	1.22
Fourth	2.42	2.38	2.59	2.19	2.53	3.49	2.32	4.39	3.75	3.79
Months:										
January	1.17	1.09	1.22	.99	1.18	1.51	1.06	2.50	1.23	1.07
February	1.25	1.18	1.24	1.02	1.23	1.55	1.04	2.07	1.25	1.08
March	1.20	1.17	1.23	.94	1.21	1.47	1.00	1.86	1.20	1.06
April	1.19	1.17	1.22	.93	1.22	1.39	.93	1.70	1.19	1.14
May	1.18	1.16	1.21	.86	1.20	1.33	.91	1.54	1.24	1.14
June	1.19	1.14	1.23	.88	1.23	1.33	.88	1.52	1.24	1.15
July	1.20	1.13	1.24	.91	1.23	1.38	.86	1.49	1.22	1.15
August	1.26	1.16	1.26	.94	1.28	1.41	1.05	1.47	1.21	1.15
September	1.30	1.29	1.44	1.07	1.41	1.93	1.31	1.62	1.46	1.37
October	1.56	1.47	1.44	1.39	1.45	2.60	1.68	2.84	2.52	2.54
November	2.55	2.59	2.91	2.30	2.90	3.69	2.70	5.43	4.74	4.74
December	3.15	3.07	3.42	2.87	3.24	4.17	2.59	4.91	4.00	4.06
Year 1917	2.68	2.38	2.70	2.13	2.77	3.39	2.38	4.31	3.30	3.33
Quarters:										
First	2.92	2.72	3.17	2.24	3.25	4.02	2.51	5.53	4.30	4.52
Second	2.88	2.16	2.67	1.74	2.90	4.23	2.27	5.27	3.78	3.77
Third	2.61	2.30	2.61	2.22	2.62	2.94	2.46	4.15	2.74	2.68
Fourth	2.33	2.33	2.33	2.33	2.30	2.36	2.29	2.30	2.37	2.35

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Spot prices of bituminous coal and coke f. o. b. mines, 1913–1918—Continued.

	Bituminous coal.									
	Carterville and Franklin, Ill.	Mount Olive, Ill.	Springfield, Ill.	Standard, Ill.	Clinton, Ind.	Eastern Kentucky.	Western Kentucky.	Georges Creek, Md.	Hocking, Ohio.	Pittsburgh No. 8, Ohio.
Market	St. Louis	St. Louis	Chicago	St. Louis	Chicago	Louisville	Louisville	Boston	Columbus, Detroit.	Columbus, Detroit.
Base price	$1.16	$1.24	$1.08	$0.91	$1.13	$1.52	$0.98	$1.54	$1.19	$1.12
Year 1917—Continued.										
Months:										
January	3.30	3.25	3.62	2.62	3.57	4.02	2.65	5.72	4.48	4.93
February	2.98	2.73	3.32	2.48	3.28	4.15	2.55	5.19	4.70	4.88
March	2.47	2.17	2.58	1.62	2.89	3.90	2.34	5.67	3.71	3.74
April	2.29	1.76	2.18	1.31	2.48	3.46	1.72	4.63	2.82	2.76
May	3.19	2.40	2.78	2.18	3.12	4.51	2.46	5.63	4.20	4.17
June	3.16	2.32	3.05	1.73	3.11	4.72	2.62	5.55	4.32	4.37
July	2.93	2.44	2.87	2.20	2.94	3.38	2.81	5.46	3.08	3.00
August	2.88	2.45	2.93	2.43	2.93	3.38	2.57	5.00	3.08	3.00
September	2.02	2.02	2.02	2.02	2.00	2.06	1.99	2.00	2.07	2.05
October	2.02	2.02	2.02	2.02	2.00	2.06	1.99	2.00	2.07	2.05
November	2.48	2.48	2.48	2.48	2.45	2.51	2.44	2.45	2.52	2.50
December	2.48	2.48	2.48	2.48	2.45	2.51	2.44	2.45	2.52	2.50
Year 1918	2.43	2.43	2.43	2.43	2.40	2.98	2.40	2.76	2.54	2.46
Quarters:										
First	2.48	2.48	2.48	2.48	2.45	2.51	2.44	2.72	2.52	2.50
Second	2.46	2.46	2.46	2.46	2.43	3.18	2.41	2.82	2.49	2.47
Third	2.39	2.39	2.39	2.39	2.37	3.11	2.35	2.75	2.60	2.44
Fourth	2.39	2.39	2.39	2.39	2.37	3.11	2.38	2.75	2.57	2.44
Months:										
January	2.48	2.48	2.48	2.48	2.45	2.51	2.44	2.45	2.52	2.50
February	2.48	2.48	2.48	2.48	2.45	2.51	2.44	2.85	2.52	2.50
March	2.48	2.48	2.48	2.48	2.45	2.51	2.44	2.85	2.52	2.50
April	2.49	2.49	2.49	2.49	2.45	3.21	2.44	2.85	2.52	2.50
May	2.49	2.49	2.49	2.49	2.47	3.21	2.44	2.85	2.52	2.50
June	2.39	2.39	2.39	2.39	2.37	3.11	2.34	2.75	2.42	2.40
July	2.39	2.39	2.39	2.39	2.37	3.11	2.34	2.75	2.62	2.44
August	2.39	2.39	2.39	2.39	2.37	3.11	2.34	2.75	2.62	2.44
September	2.39	2.39	2.39	2.39	2.37	3.11	2.38	2.75	2.57	2.44
October	2.39	2.39	2.39	2.39	2.37	3.11	2.38	2.75	2.57	2.44
November	2.39	2.39	2.39	2.39	2.37	3.11	2.38	2.75	2.57	2.44
December	2.39	2.39	2.39	2.39	2.37	3.11	2.38	2.75	2.57	2.44

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	Bituminous coal—Continued.							Coke.	
	Clearfield, Pa.	Pittsburgh, Pa.	Somerset and Cambria, Pa.	Kanawha, W. Va.	New River and Pocahontas, W. Va.	Alabama.	Weighted average of all districts.	Birmingham, Ala.	Connellsville, Pa.
Market	Boston	Pittsburgh	Boston	Columbus	Boston	Birmingham		Birmingham	Connellsville.
Base price	$1.12	$1.26	$1.30	$1.16	$1.30	$1.33	$1.27	$2.90	$2.01
Year 1913	1.19	1.27	1.35	1.19	1.34	1.38	1.29	3.20	2.36
Quarters:									
First	1.37	1.28	1.51	1.22	1.41	1.36	1.34	3.33	2.95
Second	1.07	1.24	1.34	1.08	1.27	1.35	1.23	3.31	2.15
Third	1.16	1.24	1.34	1.16	1.37	1.34	1.27	3.11	2.43
Fourth	1.17	1.32	1.31	1.28	1.33	1.48	1.32	3.04	1.90
Months:									
January	1.71	1.32	1.38	1.39	1.35	1.36	1.47	3.34	3.90
February	1.24	1.26	1.35	1.17	1.21	1.36	1.29	3.34	2.54
March	1.17	1.26	1.39	1.11	1.16	1.36	1.25	3.32	2.42
April	1.04	1.24	1.32	1.10	1.23	1.36	1.24	3.28	2.18
May	1.07	1.27	1.31	1.08	1.20	1.36	1.23	3.32	2.15
June	1.11	1.21	1.36	1.06	1.30	1.34	1.23	3.32	2.13
July	1.13	1.22	1.33	1.13	1.30	1.34	1.25	3.00	2.46
August	1.19	1.27	1.35	1.16	1.37	1.34	1.28	2.89	2.51
September	1.15	1.24	1.33	1.19	1.34	1.34	1.29	3.45	2.31
October	1.20	1.36	1.35	1.20	1.37	1.36	1.33	3.26	2.10
November	1.16	1.36	1.31	1.37	1.32	1.47	1.35	3.02	1.84
December	1.14	1.23	1.27	1.28	1.31	1.61	1.28	2.83	1.77
Year 1914	1.07	1.17	1.26	1.08	1.23	1.26	1.22	2.79	1.74
Quarters:									
First	1.10	1.24	1.27	1.13	1.27	1.26	1.25	2.64	1.89
Second	1.08	1.22	1.26	1.09	1.25	1.25	1.23	2.80	1.81
Third	1.05	1.12	1.27	1.06	1.25	1.25	1.20	2.87	1.71
Fourth	1.04	1.09	1.22	1.04	1.15	1.27	1.20	2.85	1.55
Months:									
January	1.12	1.25	1.27	1.19	1.28	1.27	1.27	2.75	1.87
February	1.09	1.24	1.26	1.09	1.28	1.27	1.24	2.61	1.87
March	1.09	1.24	1.28	1.10	1.25	1.25	1.24	2.57	1.92
April	1.09	1.22	1.29	1.09	1.27	1.26	1.24	2.78	1.88
May	1.09	1.24	1.27	1.09	1.27	1.25	1.24	2.79	1.79
June	1.05	1.19	1.23	1.08	1.20	1.25	1.21	2.84	1.77
July	1.02	1.19	1.23	1.08	1.12	1.25	1.20	2.84	1.76
August	1.05	1.16	1.28	1.05	1.30	1.25	1.21	2.90	1.72
September	1.07	1.00	1.30	1.05	1.33	1.25	1.20	2.88	1.66
October	1.06	1.05	1.28	1.06	1.27	1.25	1.21	2.85	1.61
November	1.03	1.14	1.20	1.02	1.09	1.25	1.19	2.83	1.53
December	1.03	1.09	1.18	1.05	1.10	1.30	1.20	2.86	1.51

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Spot prices of bituminous coal and coke f. o. b. mines, 1913–1918—Continued.

	Bituminous coal—Continued.							Coke.	
	Clearfield, Pa.	Pittsburgh, Pa.	Somerset and Cambria, Pa.	Kanawha, W. Va.	New River and Pocahontas, W. Va.	Alabama.	Weighted average of all districts.	Birmingham, Ala.	Connellsville, Pa.
Market	Boston	Pittsburgh	Boston	Columbus	Boston	Birmingham		Birmingham	Connellsville.
Base price	$1.12	$1.26	$1.30	$1.16	$1.30	$1.33	$1.27	$2.90	$2.01
Year 1915	1.10	1.04	1.31	1.04	1.22	1.25	1.19	2.84	1.75
Quarters:									
First	1.06	1.11	1.24	1.04	1.17	1.25	1.18	2.86	1.52
Second	1.01	.99	1.24	1.02	1.19	1.25	1.16	2.80	1.54
Third	1.01	.94	1.23	1.03	1.22	1.25	1.16	2.80	1.60
Fourth	1.35	1.10	1.53	1.07	1.28	1.25	1.26	2.90	2.33
Months:									
January	1.07	1.12	1.25	1.07	1.13	1.25	1.20	2.87	1.52
February	1.07	1.13	1.25	1.04	1.18	1.25	1.19	2.85	1.52
March	1.04	1.09	1.23	1.02	1.21	1.25	1.17	2.85	1.53
April	1.02	1.05	1.23	1.02	1.12	1.25	1.16	2.87	1.53
May	1.00	.98	1.23	1.02	1.21	1.25	1.16	2.83	1.53
June	1.00	.95	1.25	1.03	1.24	1.25	1.15	2.70	1.57
July	1.00	.93	1.23	1.03	1.18	1.25	1.14	2.65	1.65
August	1.00	.94	1.23	1.03	1.21	1.25	1.15	2.84	1.53
September	1.02	.96	1.24	1.03	1.27	1.25	1.18	2.90	1.62
October	1.05	.99	1.27	1.04	1.27	1.25	1.20	2.90	2.04
November	1.14	1.12	1.30	1.08	1.27	1.25	1.23	2.90	2.30
December	1.87	1.18	2.03	1.10	1.29	1.25	1.36	2.91	2.65
Year 1916	1.98	2.07	2.31	1.71	2.13	1.64	1.78	3.47	3.82
Quarters:									
First	1.97	1.43	2.18	1.17	1.29	1.30	1.44	3.05	3.27
Second	1.32	1.41	1.53	.96	1.26	1.37	1.31	3.40	2.43
Third	1.33	1.41	1.53	1.28	1.68	1.48	1.40	3.46	2.84
Fourth	3.31	4.02	3.99	3.44	4.29	2.40	2.98	3.96	6.72
Months:									
January	2.59	1.58	2.79	1.16	1.30	1.25	1.54	3.01	2.96
February	1.89	1.44	2.13	1.20	1.29	1.32	1.44	2.93	3.38
March	1.42	1.27	1.63	1.15	1.23	1.32	1.33	3.21	3.48
April	1.48	1.23	1.67	.96	1.27	1.35	1.32	3.37	2.44
May	1.31	1.28	1.54	.96	1.26	1.37	1.29	3.41	2.33
June	1.16	1.72	1.38	.96	1.24	1.38	1.33	3.42	2.51

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July	1.21	1.34	1.38	1.06	1.21	1.42	1.30	3.44	2.75
August	1.27	1.35	1.48	1.21	1.54	1.46	1.35	3.44	2.86
September	1.51	1.58	1.73	1.59	2.19	1.56	1.56	3.49	2.93
October	2.45	2.56	2.60	2.58	2.80	1.76	2.11	3.44	4.85
November	3.77	4.92	4.14	3.95	4.77	2.33	3.36	3.76	6.91
December	3.71	4.59	5.13	3.85	5.30	3.11	3.46	4.67	8.39
Year 1917	3.78	3.58	3.88	3.19	3.80	3.05	3.08	6.80	9.24
Quarters:									
First	4.75	4.79	5.05	3.82	4.88	3.01	3.67	5.24	9.61
Second	4.81	4.36	5.04	3.82	4.80	3.53	3.50	7.20	8.84
Third	3.07	2.84	3.15	2.80	3.17	2.98	2.71	8.11	12.50
Fourth	2.80	2.31	2.30	2.33	2.36	2.68	2.44	6.64	6.02
Months:									
January	4.62	4.68	4.96	3.46	4.96	3.01	3.73	5.00	9.51
February	4.46	5.21	4.71	4.15	4.83	3.01	3.75	5.19	9.66
March	5.16	4.49	5.48	3.85	4.87	3.01	3.53	5.52	9.66
April	4.41	3.51	4.66	3.21	3.96	3.26	3.00	6.46	7.43
May	5.13	4.61	5.36	4.15	5.11	3.61	3.72	7.74	7.83
June	4.89	4.97	5.11	4.11	5.34	3.71	3.77	7.39	11.26
July	3.46	3.25	3.54	3.34	3.48	3.42	2.98	7.78	12.76
August	3.74	3.25	3.91	3.02	3.97	3.42	3.03	8.27	13.59
September	2.00	2.01	2.00	2.03	2.06	2.11	2.12	8.27	11.14
October	2.00	2.01	2.00	2.08	2.06	2.38	2.15	7.80	6.00
November	2.45	2.46	2.45	2.48	2.51	2.83	2.58	6.06	6.06
December	2.45	2.46	2.45	2.48	2.51	2.83	2.59	6.06	6.06
Year 1918	2.92	2.40	2.92	2.59	2.50	2.67	2.67	7.08	6.03
Quarters:									
First	2.75	2.46	2.75	2.48	2.51	2.83	2.64	6.65	6.06
Second	3.02	2.43	3.02	2.61	2.58	2.56	2.71	7.03	6.06
Third	2.95	2.36	2.95	2.63	2.49	2.76	2.67	7.19	6.06
Fourth	2.95	2.36	2.95	2.63	2.49	2.83	2.67	7.46	6.03
Months:									
January	2.45	2.46	2.45	2.48	2.51	2.83	2.60	6.06	6.03
February	2.75	2.46	2.75	2.48	2.51	2.38	2.64	6.92	6.03
March	3.06	2.46	3.05	2.48	2.51	2.38	2.67	6.97	6.03
April	3.06	2.46	3.06	2.48	2.51	2.38	2.71	7.03	6.03
May	3.06	2.46	3.06	2.73	2.59	2.68	2.75	7.03	6.03
June	2.95	2.36	2.95	2.63	2.49	2.73	2.66	7.03	6.03
July	2.95	2.36	2.95	2.63	2.49	2.73	2.66	7.05	6.03
August	2.95	2.36	2.95	2.63	2.49	2.73	2.67	7.09	6.03
September	2.95	2.36	2.95	2.63	2.49	2.83	2.67	7.43	6.03
October	2.95	2.36	2.95	2.63	2.49	2.83	2.67	7.46	6.03
November	2.95	2.36	2.95	2.63	2.49	2.83	2.67	7.46	6.03
December	2.95	2.36	2.95	2.63	2.49	2.83	2.67	7.46	6.03

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ANTHRACITE.

The production of Pennsylvania anthracite represents only 15 per cent of the total coal output of the United States, but the industry is so centralized, both geographically and commercially, so large a portion of the product goes to one class of consumers, the householders, and the factors limiting production are so different from those affecting bituminous coal that the industry is in a separate class from the bituminous-coal industry and must be discussed separately.

The upper limit of production is not at all times the demand, because the larger companies have facilities for storing more than 10 per cent of the total annual output during periods of slack demand. The upper limit of demand is established by the domestic user, for the prepared or domestic sizes of anthracite represent 60 per cent of the total output and the profit-producing part of the business. The history of the production of anthracite is represented by the increase in population of the United States, whereas that of bituminous coal follows the rise and fall of industry.

The prices of the domestic sizes of anthracite are, to a large extent, established by the circular prices of the larger of the high-cost producing companies. The prices of the steam sizes are determined by competition with bituminous coal. Prior to 1916 pea coal was considered a steam size and no summer reductions in its price were offered the trade, as in the prices of the domestic sizes. Beginning with April, 1916, pea coal was classed as a domestic or prepared size and the steam sizes have been buckwheat coal and smaller.

Since 1903 it has been the policy of the anthracite companies to offer a reduction in the price of domestic sizes each summer, beginning with a reduction of 50 cents a gross ton in April, and reaching the full price in September by 10 cent increases each month. This policy has been adopted to encourage the purchase and storage of anthracite by the householder and has been of great benefit to the industry because it has permitted more uniform operation of the mines. These summer reductions in price to the consumer are not accompanied by corresponding decrease in wages to the mine labor. Although it is probable that the loss or lessening of profit on summer sales is offset by greater profits on winter sales, it is fair to assume that the average price for the year, as a result of more uniform and regular operation of the mines, is less than it would be if only such anthracite were produced as was consumed month by month.

The steam sizes of anthracite are sold in competition with bituminous coal and are therefore marketed in much the same manner as bituminous coal. The domestic sizes are sold through selling agents and jobbers to retail dealers, who in turn distribute the product to the householder. The contract year for anthracite is the same as for bituminous coal, April to April, but the wage agreements have until recently been made to cover a four-year period instead of a two-year period, like those on bituminous coal. On domestic sizes of anthracite there is not the difference in current quoted prices and contract prices found in the bituminous trade. About 75 per cent of the total output of anthracite is produced by a comparatively few companies, generally designated the "railroad companies," as distinguished from the independents, who produce

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the remaining 25 per cent. These larger companies issue regular circulars quoting prices, which are generally adhered to by them; the independents sell above or below the circular prices, according to the state of the market.

Current quotations of both company and independent coal from January 1, 1913, to September 1, 1917, on the several sizes of anthracite described separately in this report[1] were taken from the trade paper Coal Age. Prices fixed by the President September 1, 1917, and subsequently modified by the Fuel Administrator were used from September 1, 1917, to December, 1918. About 5,000 quotations were thus abstracted, tabulated, and reduced to monthly averages in the same general manner as the bituminous prices. (See pp. 20–21.)

Because Pennsylvania anthracite is invariably sold at the mines by the gross ton (2,240 pounds) the prices are given in the tables in that unit. Many of the quotations obtained were prices for coal delivered, as, for instance, at New York harbor points, and it was necessary to subtract from each such quotation the prevailing freight rate.[2]

To combine the quotations for company and independent coal the figures were averaged, the price for company coal being given three times the weight of the price for the independent coal.

The tables of average prices realized were calculated from the current circular prices reduced to harmonize with the actual annual average realization prices, by sizes, as reported to the Geological Survey.

The diagrams show relative prices of anthracite calculated in the same manner as for bituminous coal. (See pp. 20–21.)

PRICES.

The diagrams and tables on succeeding pages present the data on prices of Pennsylvania anthracite. It will at once be noted that there is an important difference in the general appearance of the curves for the two classes of coal. Prices of anthracite as a whole, compared with the pre-war level, did not advance to so great an extent as prices of bituminous coal. Prices of steam sizes of anthracite, however, recorded a more marked rise than prices of bituminous coal as a whole, but less than prices of central Pennsylvania coal, with which anthracite enters into competition on the Atlantic seaboard. The prices of domestic sizes in 1913, 1914, and 1915 exhibited the summer reduction, greatest in April. Prices were advanced April 1, 1916 (after a wage advance), and the summer reductions for that year do not appear as depressions in the curve but as a low point for the year. From April the prices of the domestic sizes advanced steadily to a maximum for the year in November, 1916, owing to continued heavy demand supplemented in October and November by cold weather. After reaching the high point in November, 1916, prices of domestic sizes, including pea, declined, with lessening demand and warmer weather, to a low point in April, 1917.

[1] Egg, stove, chestnut, pea, and the steam sizes represent 95 per cent of the total commercial production. See current reports on the production of coal in the reports of the United States Geological Survey on mineral resources of the United States.

[2] The necessary records of freight rates were obtained through the courtesy of Mr. E. W. Parker, director of the Anthracite Bureau of Information.

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The rate of production of anthracite is shown graphically by the monthly shipments as reported by the Anthracite Bureau of Information in figure 36.

The high prices for domestic sizes of anthracite in the winter of 1916–17 aroused so much interest in the consuming public that Congress directed the Federal Trade Commission to investigate conditions, and that body, though without legal authority to fix prices, laid so firm a restraining hand upon the industry as a whole, to and including the retail dealer, that prices were well under control in the summer of 1917 and did not rise as they had the preceding year and as the prices of bituminous coal did. Summer reductions were offered as usual by the larger companies. No prices of anthracite were agreed upon by the Lane-Peabody committee.

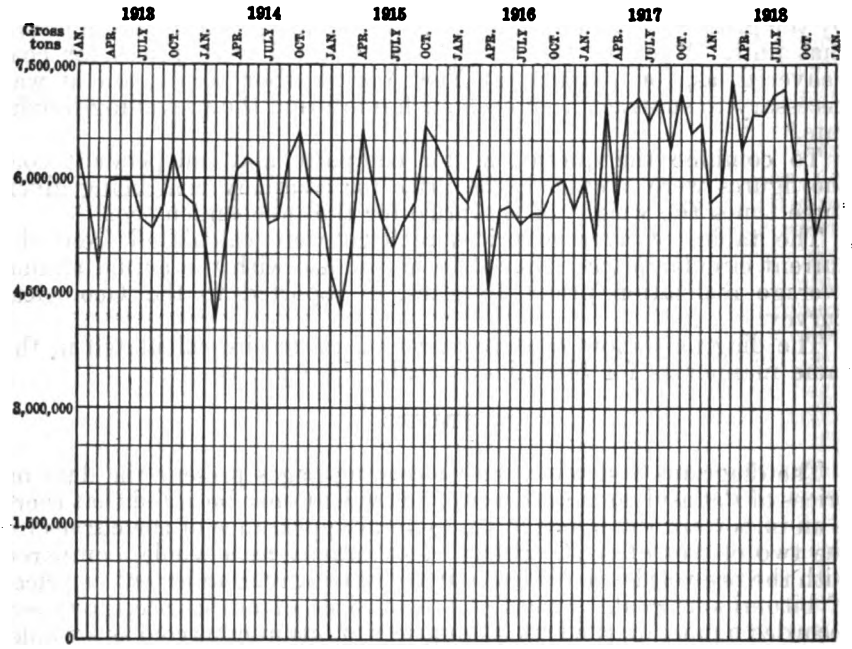

FIGURE 36.—Shipments of Pennsylvania anthracite, by months, 1913–1918.

Prices of anthracite came definitely under the control of the Government on September 1, 1917, when a scale of mine prices was announced by the President. The President's order was in part as follows:

4. Effective September 1, 1917, the maximum prices per ton of 2,240 pounds free on board cars at the mines for the grades and sizes of anthracite coal hereinafter specified shall not exceed the prices indicated in paragraph 5 when such coal is produced and sold by the Philadelphia & Reading Coal & Iron Co., Lehigh Coal & Navigation Co., Lehigh & Wilkes-Barre Coal Co., Hudson Coal Co., Delaware & Hudson Co., Scranton Coal Co., Lehigh Valley Coal Co., Coxe Bros. & Co., Pennsylvania Coal Co., Hillside Coal & Iron Co., Delaware, Lackawanna & Western Railroad Co., Delaware, Lackawanna & Western Coal Co., Susquehanna Coal Co., Susquehanna Collieries Co., Lytle Coal Co., or the M. A. Hanna Coal Co.

5. The grades and sizes for which the maximum prices are specified are as follows: White ash anthracite coal of the grade that between January 1, 1915, and January 1, 1917, was uniformly sold and recognized in the coal trade as coal of white-ash grade;

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red ash anthracite coal of the grade that between January 1, 1915, and January 1, 1917, was uniformly sold and recognized in the trade as coal of red-ash grade; and Lykens Valley anthracite coal that is mined exclusively from the Lykens Valley seams and of the grade that between January 1, 1915, and January 1, 1917, was uniformly sold and recognized in the coal trade as coal of Lykens Valley grade.

White-ash grade:	
Broken	$4.55
Egg	4.45
Stove	4.70
Chestnut	4.80
Pea	4.00
Red-ash grade:	
Broken	4.75
Egg	4.65
Stove	4.90
Chestnut	4.90
Pea	4.10
Lykens Valley grade:	
Broken	5.00
Egg	4.90
Stove	5.30
Chestnut	5.30
Pea	4.35

6. Producers of anthracite coal who are not specified in paragraph 4 shall not sell the various grades and sizes of anthracite coal at prices that exceed by more than 75 cents per ton of 2,240 pounds free on board cars at the mines the prices enumerated in paragraph 5: *Provided*, That any producer of anthracite coal who incurs the expense of rescreening it at Atlantic or Lake ports for transshipment by water may increase the price thereof by not more than 5 cents per ton of 2,240 pounds.

7. Producers of anthracite coal specified in paragraph 4 of these regulations shall not sell anthracite coal to producers of anthracite coal not specified in paragraph 4.

8. Dealers and selling agents shall not sell coal produced by the producers included in paragraph 4 on the basis of the prices fixed at the mine for coal produced by producers not specified in said paragraph.

With the exception of the price of pea coal, the prices thus fixed by the President were substantially those in effect at the time. The increase above the market in the price of pea coal as fixed by the President on the advice of the Federal Trade Commission was, on October 1, reduced 60 cents a gross ton at the mine by order of the Fuel Administrator. The prices of anthracite were, on December 1, 1917, advanced by 35 cents a gross ton, after the wage increase authorized by the President.

Summer reductions in the prices of domestic sizes were offered to the trade by the producers in 1918, although not ordered or required by the Fuel Administrator. Instead, however, of a reduction of 50 cents a ton in April, followed by 40 cents in May, and so on, a reduction of 30 cents a gross ton at the mine was offered for five months, April to August, inclusive. This was done to assist in equalizing distribution and to prevent complaints on the part of those who, having ordered in April, would not have been able to procure their coal until later in the summer.

On November 1, 1918, the Fuel Administrator authorized an advance in the maximum price of prepared sizes of Pennsylvania anthracite of $1.05 a gross ton, after an increase in wages granted to the mine laborers in the anthracite regions. On November 15, 1918, a maximum price for steam sizes of anthracite was for the first time fixed by the Government. The maximum price thus established was 50 cents a ton less than that fixed for pea coal.

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DIAGRAMS OF RELATIVE PRICES OF ANTHRACITE, 1913–1918.

ALL SIZES.

Figure 38 shows the relative spot prices in this period compared with the average spot prices in the 12 months preceding the war, July, 1913, to June, 1914. Figure 37 shows the relative range in estimated average realization prices from all sales and includes both spot and contract transactions. The spot prices are taken from the New York market quotations of the Coal Age and the average realization prices from annual reports of operators compiled by the Geological Survey. Tables of actual prices and of the computed

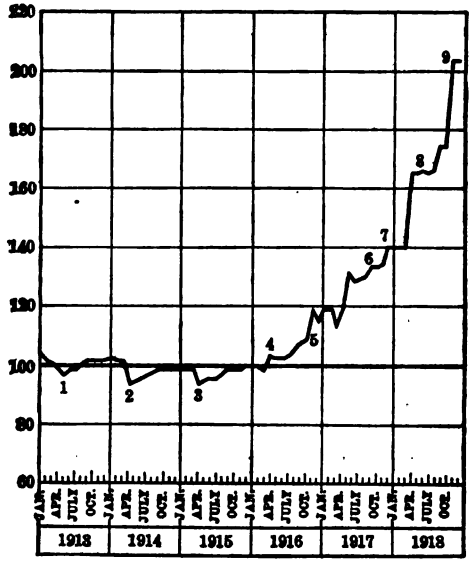

FIGURE 37.—Relative prices realized for Pennsylvania anthracite, all sizes, by months, 1913–1918.

relative prices from which these diagrams were drawn are given on pages 104–111.

1–3. The annual summer reductions in prices of domestic sizes of anthracite for 1913, 1914, and 1915 are shown at these points.

4 and 5. The summer reductions in 1916 were based on an increase in price over the previous year, reached in September and October, 1916 (5).

6. The prices of anthracite were fixed by the President, September 1, 1917 (6). In the period between October, 1916, and September, 1917 (5 and 6), prices of prepared sizes reached a maximum in November, 1916, pea coal a maximum in August, 1917, and steam sizes in June, 1917.

7. An increase of 35 cents a gross ton was allowed by the President, effective December 1, to cover an increase allowed mine labor.

8. The summer reduction of 30 cents, effective April to August, inclusive, offered by the anthracite operators in lieu of the sliding scale of previous years, is shown at (8). A temporary rise in the price of steam sizes in June and an increase again in August, are reflected in the diagram of all sizes, for this period.

9. An increase in price of $1.05 a gross ton, authorized November 7, 1918, and effective November 1, accounts for the sharp rise in the curve at the end of 1918.

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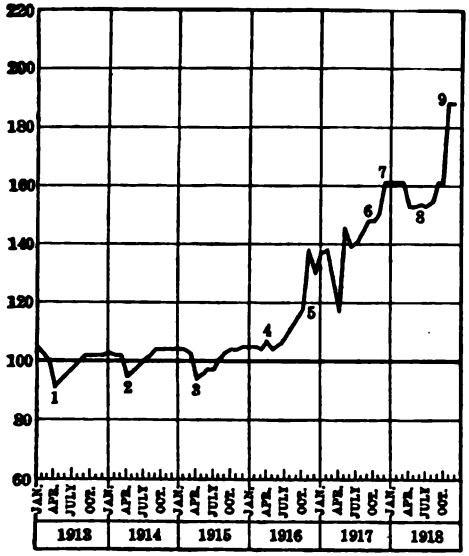

FIGURE 38.—Relative spot prices of Pennsylvania anthracite, all sizes, by months, 1913–1918.

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STOVE SIZE.

Figure 40 shows the relative spot prices in this period compared with the average spot prices in the 12 months preceding the war, July, 1913, to June, 1914. Figure 39 shows the relative range in estimated average realization prices from all sales and includes both spot and contract transactions. The spot prices are taken from the New York market quotations of the Coal Age and the average realization prices from annual reports of operators compiled by the Geological Survey. Tables of actual prices and of the computed relative prices from which these diagrams were drawn are given on pages 104–111.

1–3. The annual summer reductions in the price of stove coal in 1913, 1914, and 1915 are shown at these points.

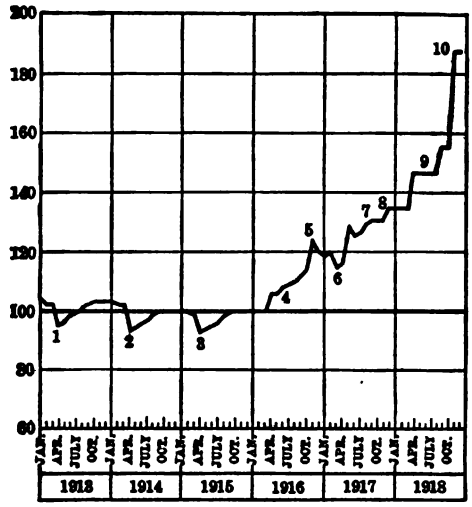

FIGURE 39.—Relative prices realized for Pennsylvania anthracite, stove size, by months, 1913–1918.

4, 5. The summer reductions in 1916 were based on an increase in price over the preceding year and resulted, therefore, in a steady increase in price through the summer to the new level of circular prices for September. The highest price for stove coal in the years 1913–1917 was reached in November, 1916 (5).

6. From the low prices in April, 1917, the advance was rapid until fall.

7. Prices of anthracite were fixed by the President, September 1, 1917 (7).

8. An increase of 35 cents a gross ton was allowed by the President, effective December 1, to cover an increase allowed mine labor.

9. The summer reduction of 30 cents, effective April to August, inclusive, offered by the anthracite operators in lieu of the sliding scale of the previous years, is shown at (9). In the diagram based on spot prices this reduction appears as a sag in the curve. In the diagram based on average realization, the summer reduction in 1918 is preceded by a rise, the extent of which is subject to correction when the actual realization for the year 1918 has been compiled by the Geological Survey from the returns of the operators.

10. An increase in price of $1.05 a gross ton, authorized November 7, 1918, and effective November 1, accounts for the very sharp rise in the curve at the end of 1918.

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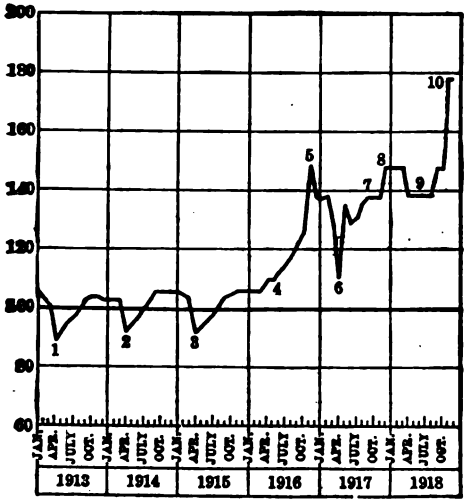

FIGURE 40.—Relative spot prices of Pennsylvania anthracite, stove size, by months, 1913–1918.

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EGG SIZE.

Figure 42 shows the relative spot prices in this period compared with the average spot prices in the 12 months preceding the war, July, 1913, to June, 1914. Figure 41 shows the relative range in estimated average realization prices from all sales and includes both spot and contract transactions. The spot prices are taken from the New York market quotations of the Coal Age and the average realization prices from annual reports of operators compiled by the Geological Survey. Tables of actual prices and of the computed relative prices from which these diagrams were drawn are given on pages 104–111.

1–3. The annual summer reductions in the price of egg coal in 1913, 1914, and 1915 are shown at these points.

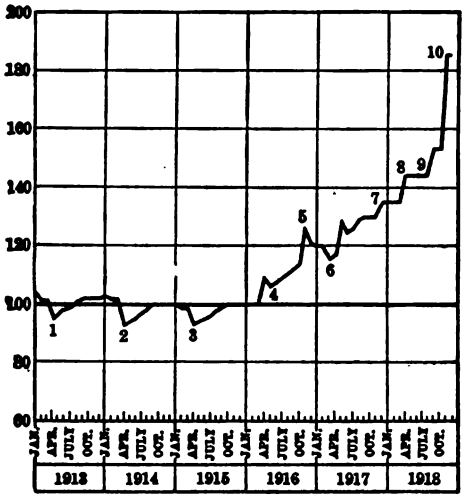

FIGURE 41.—Relative prices realized for Pennsylvania anthracite, egg size, by months, 1913–1918.

4, 5. The summer reductions in 1916 were based on an increase in price over the preceding year and resulted, therefore, in a steady increase in price through the summer to the new level of circular prices for September. The highest price for egg coal in the years 1913–1917 was reached in November, 1916 (5).

6. From the low prices in April, 1917, the advance was rapid until fall.

7. Prices of anthracite were fixed by the President, September 1, 1917 (7).

8. An increase of 35 cents a gross ton was allowed by the President, effective December 1, to cover an increase allowed mine labor.

9. The summer reduction of 30 cents, effective April to August, inclusive, offered by the anthracite operators in lieu of the sliding scale of the previous years, is shown at (9). In the diagram based on spot prices this reduction appears as a sag in the curve. In the diagram based on average realization prices, the summer reduction in 1918 is preceded by a rise, the extent of which is subject to correction when the actual realization for the year 1918 has been compiled by the Geological Survey from the returns of the operators.

10. An increase in price of $1.05 per gross ton, authorized November 7, 1918, and effective November 1, accounts for the very sharp rise in the curve at the end of 1918.

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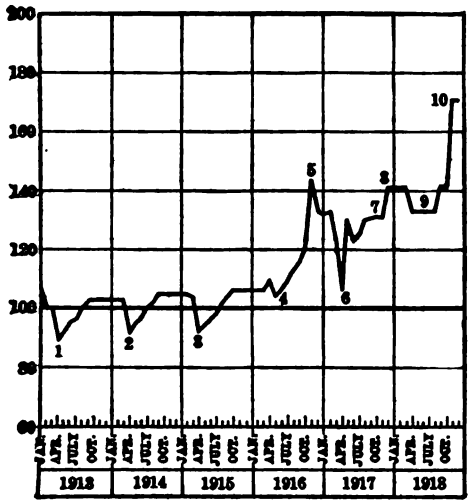

FIGURE 42.—Relative spot prices of Pennsylvania anthracite, egg size, by months, 1913–1918.

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CHESTNUT SIZE.

Figure 44 shows the relative spot prices in this period compared with the average spot prices in the 12 months preceding the war, July, 1913, to June, 1914. Figure 43 shows the relative range in estimated average realization prices from all sales and includes both spot and contract transactions. The spot prices are taken from the New York market quotations of the Coal Age and the average realization prices from annual reports of operators compiled by the Geological Survey. Tables of actual prices and of the computed relative prices from which these diagrams were drawn are given on pages 104–111.

1–3. The annual summer reductions in the price of chestnut coal in 1913, 1914, and 1915 are shown at these points.

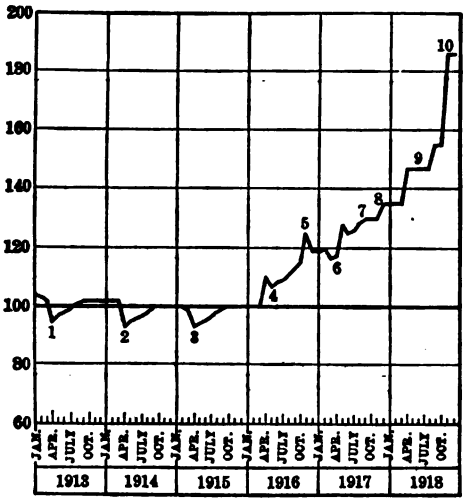

FIGURE 43.—Relative prices realized for Pennsylvania anthracite, chestnut size, by months, 1913–1918.

4, 5. The summer reductions in 1916 were based on an increase in price over the preceding year and resulted, therefore, in a steady increase in price through the summer to the new level of circular prices for September. The highest price for chestnut coal in the years 1913–1916 was reached in November, 1916 (5).

6. From the low prices in April, 1917, the advance was rapid until fall.

7. Prices of anthracite were fixed by the President, September 1, 1917 (7).

8. An increase of 35 cents a gross ton was allowed by the President, effective December 1, to cover an increase allowed mine labor.

9. The summer reduction of 30 cents, effective April to August, inclusive, offered by the anthracite operators in lieu of the sliding scale of the previous years, is shown at (9). In the diagram based on spot prices this reduction appears as a sag in the curve. In the diagram based on average realization prices the summer reduction in 1918 is preceded by a rise, the extent of which is subject to correction when the actual realization for the year 1918 has been compiled by the Geological Survey from the returns of the operators.

10. An increase in price of $1.05 per gross ton, authorized November 7, 1918, and effective November 1, accounts for the very sharp rise in the curve at the end of 1918.

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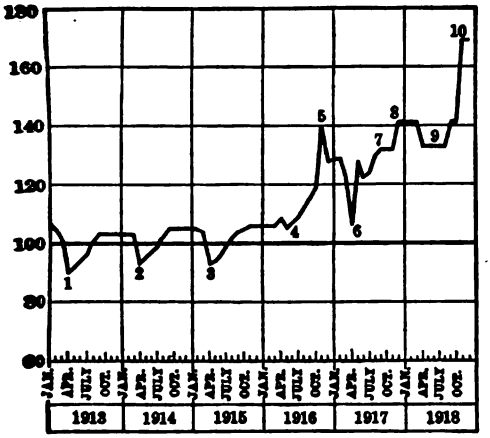

FIGURE 44.—Relative spot prices of Pennsylvania anthracite, chestnut size, by months, 1913–1918.

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PEA SIZE.

Figure 46 shows the relative spot prices in this period compared with the average spot prices in the 12 months preceding the war, July, 1913, to June, 1914. Figure 45 shows the relative range in estimated average realization prices from all sales and includes both spot and contract transactions. The spot prices are taken from the New York market quotations of the Coal Age and the average realization prices from annual reports of operators compiled by the Geological Survey. Tables of actual prices and of the computed relative prices from which these diagrams were drawn are given on pages 104–111.

1, 2. In the period from 1913 to 1916 the status of pea coal changed from a steam size to a domestic size because of the greatly increased use of this size in household

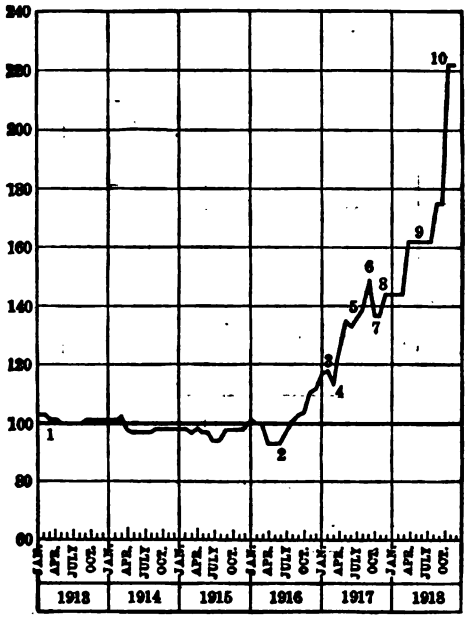

FIGURE 45.—Relative prices realized for Pennsylvania anthracite, pea size, by months, 1913–1918.

heating. In 1915 and 1916 pea coal was known as "poor man's anthracite," and until the middle of 1916 there was relatively little increase in its price. In 1916, for the first time, pea coal was formally recognized as a domestic size by its inclusion, with the other domestic sizes, in the summer scale of prices.

3. From the middle of 1916 the price of pea coal steadily advanced at a rate more than double that of the other prepared sizes. The maximum for the winter of 1916–17 was reached in February of 1917 (3).

4, 5. The prices declined in April, but began to increase in May and in August reached a new high level (5).

6, 7. The prices of pea coal were fixed by the President, September 1, 1917 (6). The price of pea coal announced on that date was about 60 cents per ton above the prevailing market price in August and accordingly, on October 1, the Fuel Administrator reduced the price by that amount (7).

8. An increase of 35 cents a gross ton was allowed by the President, effective December 1, to cover an increase allowed mine labor.

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9. The summer reduction of 30 cents, effective April to August, inclusive, offered by the anthracite operators in lieu of the sliding scale of the previous years, is shown at (9). In the diagram based on spot prices this reduction appears as a sag in the curve. In the diagram based on average realization prices, the summer reduction in 1918

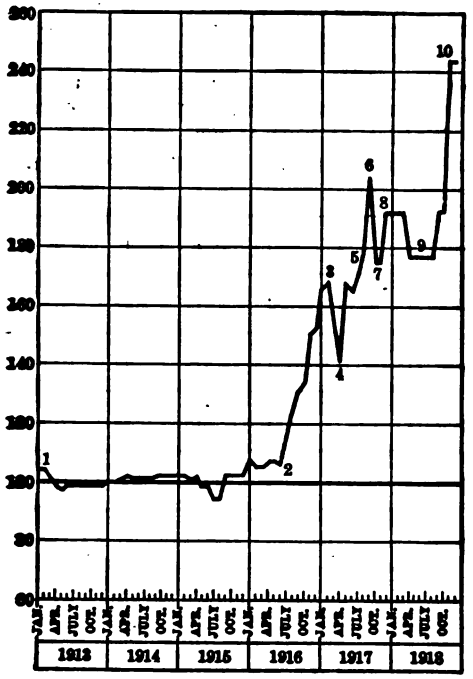

FIGURE 46.—Relative spot prices of Pennsylvania anthracite, pea size, by months, 1913–1918.

is preceded by a rise, the extent of which is subject to correction when the actual realization for the year 1918 has been compiled by the Geological Survey from the returns of the operators.

10. An increase in price of $1.05 a gross ton, authorized November 7, 1918, and effective November 1, accounts for the sharp rise in the curve at the end of 1918.

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STEAM SIZES.

Figure 48 shows the relative spot prices in this period compared with the average spot prices in the 12 months preceding the war, July, 1913, to June, 1914. Figure 47 shows the relative range in estimated average realization prices from all sales and includes both spot and contract transactions. The spot prices are taken from the New York market quotations of the Coal Age and the average realization prices from annual reports of operators compiled by the Geological Survey. Tables of actual prices and of the computed relative prices from which these diagrams were drawn are given on pages 104–111.

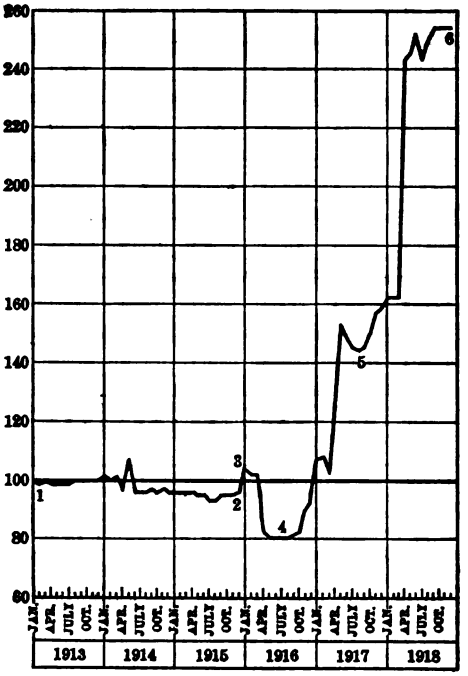

FIGURE 47.—Relative prices realized for Pennsylvania anthracite, steam sizes, by months, 1913–1918.

1–3. The prices of steam sizes followed very closely the prices of bituminous coal, with which they enter into competition. The diagrams for steam sizes will thus be found to resemble those for bituminous coals from central Pennsylvania (pp. ———). Spot prices did not vary greatly in 1913, 1914, and 1915, but there was a steady drop in the three years in the average realization prices. The sharp rise in prices in the eastern bituminous fields in the winter of 1915–16 is found also in prices of steam sizes of anthracite (3).

4, 5. The depressions in the curves representing drop in prices in the summer of 1916 were similar to those of bituminous coal, but were of greater extent. From the fall of 1916 until the end of 1918 the prices of steam sizes steadily advanced, with two recessions—a slight one in the early part of 1917 and another, more marked, in the fall of 1917 (5), when prices of bituminous coal were fixed at a lower level by the President.

6. Effective November 16, 1918, the prices of steam sizes were for the first time fixed by the Government, the maximum price established having been 50 cents under the price of pea coal in effect at the time.

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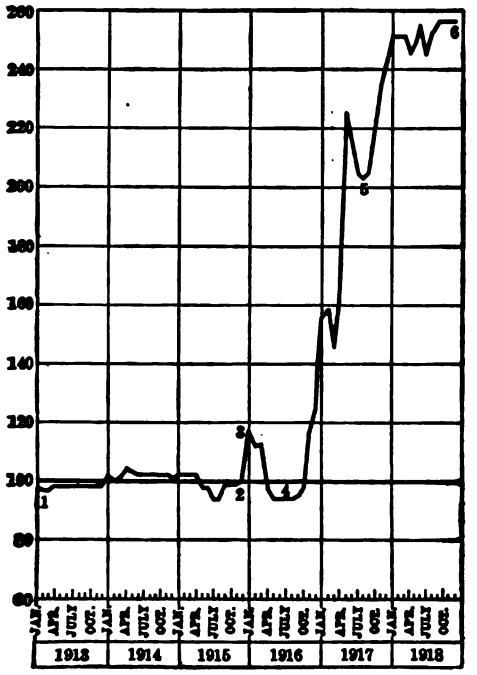

FIGURE 48.—Relative spot prices of Pennsylvania anthracite, steam sizes, by months, 1913–1918.

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TABLES OF PRICES AND RELATIVE PRICES OF ANTHRACITE COAL.

Spot prices of anthracite coal f. o. b. mines, 1913–1918.

[Unit, gross tons of 2,240 pounds.]

	Anthracite coal.					
	Size.					Weighted average of all sizes.
	Egg.	Stove.	Chestnut.	Pea.	Steam.	
Market	New York.	New York.	New York.	New York.	New York.	New York.
Base price	$3.53	$3.54	$3.78	$2.06	$1.26	$2.82
Year 1913	3.50	3.53	3.76	2.05	1.23	2.79
Quarters:						
First	3.60	3.63	3.92	2.12	1.23	2.88
Second	3.25	3.25	3.48	2.03	1.23	2.62
Third	3.52	3.54	3.76	2.08	1.24	2.80
Fourth	3.64	3.67	3.90	2.04	1.24	2.88
Months:						
January	3.73	3.79	4.03	2.14	1.24	2.96
February	3.52	3.65	3.92	2.14	1.22	2.86
March	3.54	3.59	3.82	2.07	1.22	2.82
April	3.14	3.15	3.39	2.04	1.24	2.56
May	3.25	3.25	3.49	2.00	1.23	2.62
June	3.35	3.35	3.56	2.03	1.23	2.68
July	3.41	3.42	3.62	2.03	1.23	2.72
August	3.52	3.54	3.78	2.03	1.24	2.80
September	3.64	3.65	3.88	2.04	1.24	2.87
October	3.64	3.67	3.90	2.04	1.24	2.88
November	3.64	3.68	3.89	2.04	1.24	2.88
December	3.63	3.66	3.90	2.04	1.24	2.88
Year 1914	3.58	3.60	3.83	2.08	1.28	2.85
Quarters:						
First	3.64	3.65	3.89	2.07	1.27	2.88
Second	3.34	3.34	3.58	2.09	1.30	2.70
Third	3.62	3.65	3.86	2.08	1.28	2.88
Fourth	3.71	3.75	3.98	2.09	1.28	2.94
Months:						
January	3.65	3.66	3.90	2.06	1.27	2.89
February	3.64	3.64	3.89	2.06	1.26	2.88
March	3.63	3.64	3.88	2.08	1.27	2.88
April	3.25	3.25	3.50	2.10	1.31	2.65
May	3.34	3.35	3.58	2.08	1.30	2.70
June	3.42	3.44	3.66	2.08	1.28	2.75
July	3.53	3.55	3.75	2.08	1.28	2.81
August	3.62	3.65	3.85	2.08	1.28	2.86
September	3.72	3.76	3.98	2.09	1.29	2.94
October	3.72	3.76	3.98	2.09	1.28	2.94
November	3.71	3.75	3.98	2.09	1.29	2.94
December	3.71	3.74	3.98	2.09	1.27	2.94
Year 1915	3.59	3.59	3.84	2.05	1.24	2.84
Quarters:						
First	3.69	3.71	3.95	2.09	1.26	2.98
Second	3.33	3.33	3.57	2.05	1.25	2.68
Third	3.59	3.59	3.84	1.98	1.20	2.53
Fourth	3.74	3.74	3.99	2.09	1.25	2.94
Months:						
January	3.71	3.74	3.98	2.09	1.28	2.94
February	3.70	3.71	3.96	2.09	1.28	2.93
March	3.67	3.67	3.92	2.08	1.26	2.90
April	3.25	3.25	3.50	2.09	1.28	2.64
May	3.33	3.33	3.56	2.03	1.24	2.67
June	3.40	3.40	3.64	2.03	1.24	2.72
July	3.48	3.48	3.73	1.93	1.18	2.74
August	3.60	3.60	3.85	1 93	1.18	2.83
September	3.69	3.69	3.94	2.09	1.25	2.91
October	3.73	3.73	3.97	2.09	1.25	2.93
November	3.74	3.74	4.00	2.09	1.25	2.94
December	3.75	3.75	4.00	2.09	1.26	2.95

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Spot prices of anthracite coal f. o. b. mines, 1913–1918—Continued.

	Anthracite coal.					
	Size.					Weighted average of all sizes.
	Egg.	Stove.	Chestnut.	Pea.	Steam.	
Market	New York.	New York.	New York.	New York.	New York.	New York.
Base price	$3.53	$3.54	$3.78	$2.06	$1.26	$2.82
Year 1913	4.04	4.19	4.29	2.48	1.31	3.16
Quarters:						
First	3.75	3.75	4.00	2.18	1.43	2.95
Second	3.77	3.93	4.04	2.20	1.20	2.96
Third	3.95	4.20	4.24	2.55	1.19	3.11
Fourth	4.67	4.87	4.89	3.00	1.43	3.62
Months:						
January	3.75	3.76	4.00	2.23	1.47	2.97
February	3.75	3.75	4.00	2.17	1.41	2.95
March	3.75	3.75	4.00	2.15	1.42	2.94
April	3.90	3.90	4.14	2.21	1.24	3.01
May	3.96	3.90	3.96	2.20	1.19	2.92
June	3.74	3.99	4.08	2.18	1.18	2.96
July	3.84	4.00	4.12	2.38	1.18	3.08
August	3.95	4.19	4.28	2.58	1.19	3.12
September	4.07	4.32	4.36	2.69	1.20	3.20
October	4.24	4.48	4.51	2.75	1.23	3.32
November	5.08	5.26	5.30	3.11	1.48	3.89
December	4.70	4.88	4.86	3.15	1.56	3.66
Year 1917	4.52	4.75	4.81	3.53	2.48	3.98
Quarters:						
First	4.56	4.76	4.78	3.35	1.98	3.78
Second	4.28	4.44	4.49	3.26	2.51	3.77
Third	4.55	4.79	4.86	3.80	2.57	4.05
Fourth	4.76	5.01	5.11	3.71	2.91	4.30
Months:						
January	4.66	4.85	4.87	3.41	1.96	3.86
February	4.69	4.88	4.88	3.46	2.00	3.88
March	4.34	4.56	4.60	3.17	1.83	3.62
April	3.74	3.98	4.00	2.91	2.01	3.26
May	4.62	4.81	4.85	3.46	2.84	4.11
June	4.33	4.58	4.63	3.40	2.60	3.91
July	4.40	4.65	4.70	3.52	2.56	3.94
August	4.61	4.83	4.90	3.68	2.56	4.06
September	4.64	4.89	4.99	4.19	2.58	4.16
October	4.64	4.89	4.99	3.59	2.75	4.16
November	4.64	4.89	4.99	3.59	2.96	4.22
December	4.99	5.24	5.34	3.94	3.02	4.54
Year 1918	5.04	5.29	5.39	3.99	3.17	4.56
Quarters:						
First	4.99	5.24	5.34	3.94	3.16	4.49
Second	4.99	4.94	5.04	3.64	3.14	4.32
Third	4.79	5.04	5.14	3.74	3.17	4.39
Fourth	5.09	5.94	6.04	4.64	3.23	5.04
Months:						
January	4.99	5.24	5.34	3.94	3.16	4.52
February	4.99	5.24	5.34	3.94	3.16	4.44
March	4.99	5.24	5.34	3.94	3.16	4.52
April	4.69	4.94	5.04	3.64	3.09	4.31
May	4.69	4.94	5.04	3.64	3.12	4.31
June	4.69	4.94	5.04	3.64	3.21	4.34
July	4.69	4.94	5.04	3.64	3.09	4.30
August	4.69	4.94	5.04	3.64	3.18	4.33
September	4.99	5.24	5.34	3.94	3.23	4.54
October	4.99	5.24	5.34	3.94	3.23	4.54
November	6.04	6.29	6.39	4.99	3.23	5.30
December	6.04	6.29	6.39	4.99	3.23	5.30

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Relative prices of anthracite coal, spot prices as base, f. o. b. mines, 1913–1918.

[Unit, gross ton of 2,240 pounds.]

	Anthracite coal.					
	Size.					Weighted average of all sizes.
	Egg.	Stove.	Chestnut.	Pea.	Steam.	
Market	New York..	New York..	New York..	New York..	New York..	New York.
Base price	$3.53	$3.54	$3.78	$2.06	$1.26	$2.82
Year 1913	99	100	99	100	98	99
Quarters:						
First	102	104	104	103	98	102
Second	92	92	92	99	98	93
Third	100	100	99	99	98	99
Fourth	103	104	103	99	98	102
Months:						
January	106	107	107	104	98	105
February	100	103	104	104	97	102
March	100	101	101	101	97	100
April	89	89	90	99	98	91
May	92	92	92	97	98	93
June	95	95	94	99	98	95
July	96	97	96	99	98	97
August	100	100	100	99	98	99
September	103	103	103	99	98	102
October	103	104	103	99	98	102
November	103	104	103	99	98	102
December	103	103	103	99	98	102
Year 1914	101	102	101	101	102	101
Quarters:						
First	103	103	103	101	101	102
Second	95	94	95	102	103	96
Third	102	103	102	101	102	102
Fourth	105	106	105	102	102	104
Months:						
January	103	103	103	100	101	103
February	103	103	103	100	100	102
March	103	103	103	101	101	102
April	92	92	93	102	104	94
May	95	95	95	101	103	96
June	97	97	97	101	102	98
July	100	100	99	101	102	100
August	102	103	102	101	102	102
September	105	106	105	102	102	104
October	105	106	105	102	102	104
November	105	106	105	102	102	104
December	105	106	105	102	101	104
Year 1915	102	101	102	100	98	101
Quarters:						
First	104	105	104	102	102	104
Second	94	94	94	100	99	95
Third	102	101	102	96	95	100
Fourth	106	105	105	102	99	104
Months:						
January	105	106	105	102	102	104
February	105	105	105	102	102	104
March	104	104	104	101	102	103
April	92	92	93	102	102	94
May	94	94	94	99	98	95
June	96	96	96	99	98	97
July	98	98	99	94	94	97
August	102	101	102	94	94	100
September	104	104	104	102	99	103
October	106	105	105	102	99	104
November	105	106	106	102	99	104
December	106	106	106	102	100	105

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Relative prices of anthracite coal, spot prices as base, f. o. b. mines, 1913–1918—Continued.

	Anthracite coal.					
	Size.					Weighted average of all sizes.
	Egg.	Stove.	Chestnut.	Pea.	Steam.	
Market	New York..	New York..	New York..	New York..	New York..	New York.
Base price	$3.53	$3.54	$3.78	$2.06	$1.26	$3.82
Year 1916	114	118	113	121	104	112
Quarters:						
First	106	106	106	106	113	105
Second	107	111	107	107	95	106
Third	112	119	112	124	94	110
Fourth	132	137	129	146	113	129
Months:						
January	106	106	106	106	117	105
February	106	106	106	105	112	105
March	106	106	106	105	113	104
April	110	110	109	107	96	107
May	104	110	105	107	94	104
June	106	113	107	106	94	105
July	109	115	109	116	94	108
August	112	118	112	125	94	111
September	115	122	115	131	95	114
October	120	126	119	134	96	118
November	144	148	140	151	117	138
December	133	138	128	153	125	130
Year 1917	128	134	127	172	197	141
Quarters:						
First	129	134	126	163	153	134
Second	120	125	119	158	199	134
Third	129	135	128	185	204	144
Fourth	135	141	135	180	231	153
Months:						
January	132	137	129	166	156	137
February	123	128	129	168	159	133
March	123	128	122	154	145	129
April	106	111	106	141	160	117
May	131	136	128	168	225	146
June	123	129	122	165	214	139
July	125	131	124	171	205	140
August	130	136	130	179	208	144
September	131	138	132	204	205	148
October	131	138	132	175	218	148
November	131	138	132	175	235	150
December	141	148	141	192	240	161
Year 1918	143	149	143	194	252	162
Quarters:						
First	141	148	141	192	251	159
Second	133	139	133	177	249	153
Third	136	142	136	182	252	156
Fourth	161	168	160	226	256	179
Months:						
January	141	148	141	192	251	161
February	141	148	141	192	251	158
March	141	148	141	192	251	161
April	133	139	133	177	245	153
May	133	139	133	177	248	153
June	133	139	133	177	255	154
July	133	139	133	177	245	153
August	133	139	133	177	252	154
September	141	148	141	192	256	161
October	141	148	141	192	256	161
November	171	178	169	243	256	188
December	171	178	169	243	256	188

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Spot prices of anthracite coal reduced to average realization base, f. o. b. mines, 1913–1918.

[Unit, gross ton of 2,240 pounds.]

	Anthracite coal.					
	Size.					
	Egg.	Stove.	Chestnut.	Pea.	Steam.	All sizes.
Market	New York.	New York.	New York.	New York.	New York.	New York.
Base price	$3.26	$3.36	$3.44	$2.25	$1.27	$2.60
Year 1913	3.27	3.38	3.45	2.27	1.27	2.61
Quarters:						
First	3.32	3.45	3.53	2.31	1.27	2.65
Second	3.15	3.24	3.32	2.25	1.26	2.53
Third	3.28	3.38	3.45	2.25	1.27	2.61
Fourth	3.34	3.44	3.52	2.26	1.27	2.65
Months:						
January	3.39	3.50	3.58	2.32	1.27	2.69
February	3.28	3.43	3.53	2.32	1.26	2.64
March	3.30	3.41	3.49	2.28	1.27	2.63
April	3.10	3.19	3.28	2.26	1.26	2.50
May	3.15	3.23	3.33	2.24	1.25	2.52
June	3.20	3.29	3.36	2.25	1.26	2.56
July	3.23	3.32	3.39	2.25	1.26	2.57
August	3.28	3.38	3.46	2.25	1.27	2.61
September	3.34	3.43	3.51	2.26	1.27	2.65
October	3.34	3.44	3.52	2.26	1.27	2.65
November	3.34	3.45	3.52	2.26	1.27	2.65
December	3.34	3.44	3.52	2.26	1.27	2.65
Year 1914	3.22	3.32	3.39	2.22	1.25	2.56
Quarters:						
First	3.34	3.43	3.52	2.28	1.29	2.65
Second	3.07	3.17	3.25	2.20	1.27	2.47
Third	3.21	3.31	3.38	2.19	1.22	2.55
Fourth	3.25	3.36	3.43	2.20	1.22	2.58
Months:						
January	3.35	3.44	3.52	2.27	1.29	2.66
February	3.34	3.43	3.52	2.27	1.28	2.65
March	3.34	3.43	3.51	2.29	1.29	2.65
April	3.04	3.12	3.21	2.21	1.24	2.44
May	3.08	3.17	3.25	2.19	1.26	2.47
June	3.11	3.21	3.29	2.19	1.23	2.49
July	3.16	3.26	3.33	2.19	1.22	2.53
August	3.21	3.31	3.38	2.19	1.22	2.55
September	3.25	3.36	3.43	2.20	1.23	2.58
October	3.25	3.36	3.43	2.20	1.23	2.58
November	3.25	3.36	3.43	2.20	1.23	2.58
December	3.25	3.35	3.43	2.20	1.22	2.58
Year 1915	3.19	3.28	3.36	2.18	1.21	2.54
Quarters:						
First	3.24	3.34	3.42	2.20	1.22	2.57
Second	3.07	3.16	3.24	2.18	1.21	2.46
Third	3.19	3.28	3.36	2.15	1.19	2.53
Fourth	3.25	3.36	3.43	2.21	1.21	2.56
Months:						
January	3.25	3.35	3.43	2.20	1.22	2.58
February	3.24	3.34	3.43	2.20	1.22	2.57
March	3.23	3.32	3.41	2.19	1.22	2.56
April	3.03	3.12	3.21	2.21	1.23	2.44
May	3.07	3.16	3.24	2.17	1.21	2.46
June	3.10	3.20	3.28	2.17	1.21	2.48
July	3.13	3.23	3.31	2.12	1.18	2.49
August	3.19	3.29	3.37	2.12	1.18	2.52
September	3.24	3.33	3.41	2.21	1.21	2.57
October	3.25	3.35	3.42	2.21	1.21	2.58
November	3.25	3.36	3.44	2.21	1.21	2.58
December	3.26	3.36	3.44	2.21	1.22	2.59

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Spot prices of anthracite coal reduced to average realization base, f. o. b. mines, 1913–1918—Continued.

	Anthracite coal.					
	Size.					
	Egg.	Stove.	Chestnut.	Pea.	Steam.	All sizes.
Market	New York..	New York..	New York..	New York..	New York..	New York..
Base price	$3.26	$3.26	$3.44	$2.26	$1.27	$2.60
Year 1914	3.57	3.66	3.77	2.26	1.12	2.74
Quarters:						
First	3.26	3.36	3.44	2.26	1.31	2.57
Second	3.50	3.58	3.73	2.10	1.03	2.68
Third	3.59	3.70	3.81	2.25	1.02	2.75
Fourth	3.92	4.01	4.11	2.45	1.13	2.97
Months:						
January	3.26	3.37	3.44	2.28	1.33	2.60
February	3.26	3.36	3.44	2.25	1.30	2.59
March	3.26	3.36	3.44	2.24	1.30	2.58
April	3.56	3.57	3.77	2.10	1.04	2.70
May	3.45	3.57	3.69	2.10	1.02	2.66
June	3.49	3.61	3.72	2.09	1.02	2.67
July	3.54	3.65	3.76	2.18	1.02	2.71
August	3.58	3.70	3.81	2.27	1.02	2.75
September	3.64	3.76	3.87	2.31	1.03	2.79
October	3.72	3.83	3.94	2.34	1.04	2.84
November	4.10	4.17	4.20	2.50	1.15	3.09
December	3.93	4.01	4.10	2.52	1.19	2.99
Year 1917	4.09	4.22	4.31	2.96	1.75	3.33
Quarters:						
First	3.87	3.96	4.06	2.61	1.34	3.05
Second	4.03	4.16	4.24	2.93	1.72	3.30
Third	4.18	4.33	4.41	3.17	1.85	3.41
Fourth	4.28	4.43	4.52	3.13	1.96	3.53
Months:						
January	3.91	3.99	4.10	2.63	1.36	3.08
February	3.92	4.01	4.11	2.65	1.37	3.09
March	3.77	3.86	3.98	2.53	1.30	2.97
April	3.80	3.93	4.01	2.78	1.63	3.08
May	4.21	4.34	4.40	3.03	1.95	3.45
June	4.07	4.23	4.30	2.99	1.89	3.36
July	4.11	4.27	4.34	3.05	1.85	3.37
August	4.21	4.35	4.43	3.12	1.84	3.39
September	4.23	4.38	4.47	3.35	1.85	3.47
October	4.23	4.38	4.47	3.06	1.91	3.47
November	4.23	4.38	4.47	3.06	2.00	3.50
December	4.39	4.54	4.63	3.24	2.02	3.63
Year 1918	4.89	5.12	5.21	3.82	2.90	4.35
Quarters:						
First	4.39	4.54	4.63	3.24	2.07	3.62
Second	4.69	4.94	5.04	3.64	3.14	4.32
Third	4.79	5.04	5.14	3.74	3.17	4.39
Fourth	5.09	5.94	6.04	4.64	3.23	5.07
Months:						
January	4.39	4.54	4.63	3.24	2.07	3.63
February	4.39	4.54	4.63	3.24	2.07	3.60
March	4.39	4.54	4.63	3.24	2.07	3.63
April	4.69	4.94	5.04	3.64	3.09	4.31
May	4.69	4.94	5.04	3.64	3.13	4.31
June	4.69	4.94	5.04	3.64	3.21	4.34
July	4.69	4.94	5.04	3.64	3.09	4.30
August	4.69	4.94	5.04	3.64	3.18	4.33
September	4.99	5.24	5.34	3.94	3.23	4.54
October	4.99	5.24	5.34	3.94	3.23	4.54
November	6.04	6.29	6.39	4.99	3.23	5.30
December	6.04	6.29	6.39	4.99	3.23	5.30

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Relative prices of anthracite coal based on spot prices reduced to average realization basis, f. o. b. mines, 1913–1918.

[Unit, gross ton of 2,240 pounds.

	Anthracite coal.					
	Size.					
	Egg.	Stove.	Chestnut.	Pea.	Steam.	All sizes.
Market	New York.	New York.	New York.	New York.	New York.	New York.
Base price	$3.26	$3.36	$3.44	$2.25	$1.27	$3.60
Year 1913	100	101	101	101	100	101
Quarters:						
First	102	103	103	102	100	102
Second	97	98	97	100	99	98
Third	101	101	101	100	100	101
Fourth	102	103	102	101	100	102
Months:						
January	104	104	104	103	100	104
February	101	102	103	103	99	102
March	101	102	102	101	100	101
April	95	95	95	101	99	99
May	97	98	97	100	99	97
June	98	98	98	100	99	99
July	99	99	99	100	99	99
August	101	101	101	100	100	101
September	102	102	102	101	100	102
October	102	103	102	101	100	102
November	102	103	102	101	100	102
December	102	103	102	101	100	102
Year 1914	99	99	99	98	98	99
Quarters:						
First	102	102	102	101	101	102
Second	94	94	95	97	100	95
Third	98	99	98	97	96	98
Fourth	100	100	100	98	96	99
Months:						
January	103	103	102	101	101	103
February	102	102	102	101	100	102
March	102	102	102	102	101	102
April	93	93	93	98	97	94
May	94	94	95	97	107	95
June	95	96	96	97	96	96
July	97	97	97	97	96	97
August	98	99	98	97	96	98
September	100	100	100	98	97	99
October	100	100	100	98	96	99
November	100	100	100	98	97	99
December	100	100	100	98	96	99
Year 1915	98	98	98	97	95	97
Quarters:						
First	99	100	100	98	96	99
Second	94	94	94	97	95	95
Third	98	98	98	95	94	97
Fourth	100	100	100	98	95	99
Months:						
January	100	100	100	98	96	99
February	99	100	100	98	96	99
March	99	99	99	97	96	99
April	93	93	93	98	96	94
May	94	94	94	97	95	95
June	95	95	95	97	95	95
July	96	96	96	94	93	96
August	98	98	98	94	93	97
September	99	99	99	98	95	99
October	100	100	100	98	95	99
November	109	100	100	98	95	99
December	100	100	100	98	96	100

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Relative prices of *anthracite coal based on spot prices reduced to average realization base, f. o. b. mines, 1913–1918*—Continued.

	Anthracite coal.					
	Size.					
Market	Egg.	Stove.	Chestnut.	Pea.	Steam.	All sizes.
Base price	New York.	New York.	New York.	New York.	New York.	New York.
	$3.26	$3.36	$3.44	$2.25	$1.27	$2.60
Year 1916	109	109	110	101	88	106
Quarters:						
First	100	100	100	100	103	100
Second	107	107	108	93	81	103
Third	110	110	111	100	80	106
Fourth	120	119	120	109	88	114
Months:						
January	100	100	100	101	104	100
February	100	100	100	100	102	100
March	100	100	100	100	102	99
April	100	106	110	93	82	104
May	109	106	107	93	80	103
June	106	108	108	93	80	103
July	107	109	109	97	80	104
August	109	110	111	101	80	106
September	110	112	113	103	81	108
October	112	114	115	104	82	109
November	114	124	125	111	90	119
December	126	120	119	112	93	115
Year 1917	121	126	125	132	137	128
Quarters:						
First	126	118	118	116	106	117
Second	119	124	123	131	143	127
Third	124	129	128	141	145	132
Fourth	128	132	132	139	155	136
Months:	132					
January		119	119	117	107	119
February	120	120	120	118	108	119
March	120	115	116	113	102	114
April	116	117	117	124	128	119
May	117	129	128	135	153	132
June	129	126	125	133	148	129
July	125	127	126	136	145	130
August	126	130	129	139	144	131
September	129	131	130	149	145	134
October	130	131	130	137	150	134
November	130	131	130	137	157	135
December	130	135	135	144	159	140
Year 1918	135	149	152	152	160	228	167
Quarters:						
First	135	135	135	144	162	140
Second	144	147	147	162	247	166
Third	144	150	150	166	249	167
Fourth	171	177	176	206	254	194
Months:						
January	135	135	135	144	162	140
February	135	135	135	144	162	139
March	135	135	135	144	162	140
April	144	147	147	162	243	166
May	144	147	147	162	245	166
June	144	147	147	162	252	167
July	144	147	147	162	243	166
August	144	147	147	162	250	167
September	153	156	155	175	254	175
October	153	156	155	175	254	175
November	185	188	186	222	254	204
December	185	188	186	222	254	204

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COKE.

Prices of beehive coke are presented for two producing districts, Connellsville, Pa., and Birmingham, Ala. The spot prices of beehive coke from the Connellsville district were taken from the Iron Age. The prices for furnace and foundry coke were averaged in accordance with the relative production of each in 1916, as reported to the Geological Survey by the producers. The average realized prices were computed from the spot quotations and the average annual realization prices were reported by the Geological Survey, in the same manner as for bituminous prices (see pp. 20–21), except that the assumption was made that 10 per cent of the total output was sold on the market and 90 per cent under contract and that the "coke year" was from January to December.

The quotations on Birmingham coke were also taken from the Iron Age, with due regard in combining the prices of furnace and foundry coke to the relative quantities of the two grades produced. The average prices realized were computed as for Connellsville coke. The weighted average prices for the period in which prices were fixed by the Fuel Administrator were determined from the data of the Coke Section of the Fuel Administration used in fixing the prices for the various operations. These data showed for 1917 the production of both furnace and foundry coke by individual plants and the prices fixed for each.

The range of prices for beehive coke in 1913–1918 exhibits the same tendencies as that for bituminous coal. From a high point in 1913 prices, with minor fluctuations, declined through 1914 to a low point in the middle of 1915. A temporary rise in the winter of 1915–16 was followed by a decline in the summer of 1916 and a sharp rise in the winter of 1916–17, which continued to a maximum in the summer of 1917. Government control of prices was first exercised through the War Industries Board in an order issued September 23, 1917, fixing prices on iron and steel products. This order established the price of coke as $6 a ton at the ovens, "Connellsville base." Subsequent orders of the Fuel Administrator interpreted this general order and fixed the price of coke, both beehive and by-product, at the plants and in the districts on the basis of cost of production. It is worthy of note that the Government prices in effect at the end of 1918, for both Connellsville and Birmingham coke, represent approximately the same increase over the average realization prices in the pre-war period.

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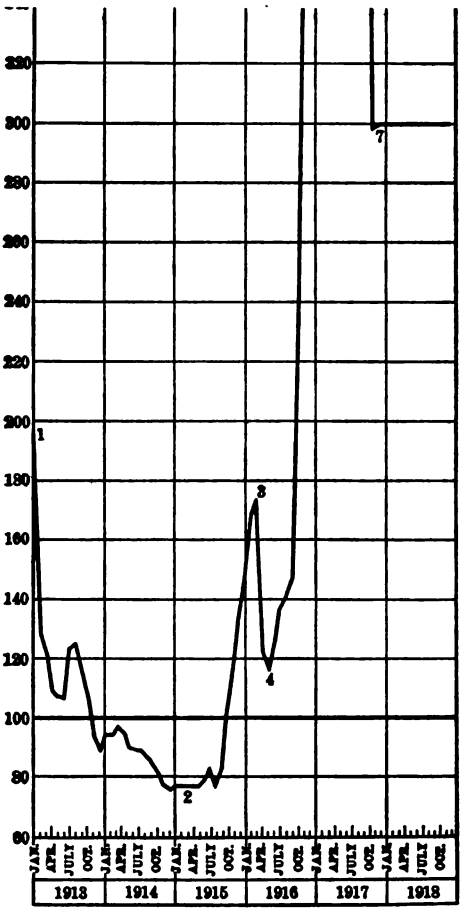

RELATIVE SPOT PRICES OF COKE PRODUCED IN THE CONNELLSVILLE DISTRICT, PA., BY MONTHS, 1913-1918.

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DIAGRAMS OF RELATIVE PRICES OF COKE, 1913–1918.

CONNELLSVILLE COKE.

Plate I shows the relative prices in this period compared with the average spot prices in the 12 months preceding the war, July, 1913, to June, 1914. Figure 49 shows the relative range in estimated average realization prices from all sales, and includes both spot and contract transactions. The spot prices are taken from the Connellsville, Pa., market quotations of the Iron Age and the average realization prices from annual reports of operators compiled by the Geologi-

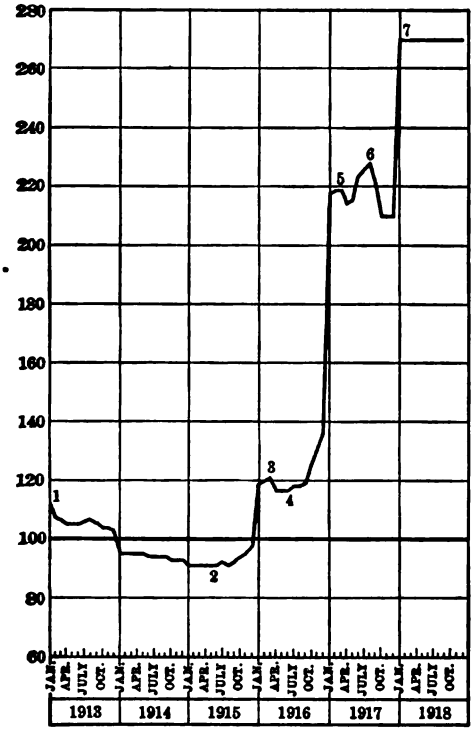

FIGURE 49.—Relative prices realized for coke produced in the Connellsville district, Pa., by months, 1913–1918.

cal Survey. Tables of actual prices and of the computed relative prices from which these diagrams were drawn are given on pages 85–87.

1–4. From $2.95 in January, 1913 (1), the spot price of Connellsville coke declined to $1.52 (2) in the first half of 1915. Beginning in September, 1915, the spot price rose to $3.48 in March, 1916 (3), but declined to $2.33 in May (4).

5. From June, 1916, to February and March, 1917 (5), spot prices rose to $9.66, but declined to $7.43 in April.

6. The maximum spot price for the six-year period was reached in August, 1917 (6), at $13.59.

7. From the peak in August, spot prices declined to $6, the Government price, in October (7).

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BIRMINGHAM COKE.

Figure 51 shows the relative spot prices in this period compared with the average spot prices in the 12 months preceding the war, July, 1913, to June, 1914. Figure 50 shows the relative range in estimated average realization prices from all sales and includes both spot and contract transactions. The spot prices are taken from the Birmingham market quotations of the Iron Age and the average realization

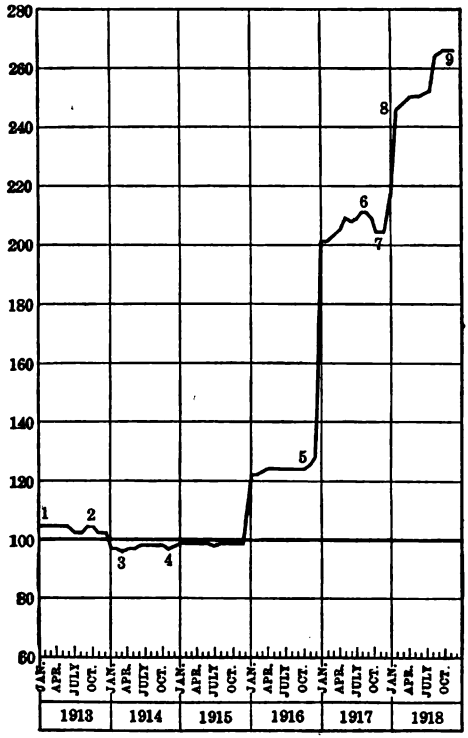

FIGURE 50.—Relative prices realized for coke produced in the Birmingham district, Ala., by months. 1913–1918.

prices from annual reports of operators compiled by the Geological Survey. Tables of actual prices and of the computed relative prices from which these diagrams were drawn are given on pages 85–87.

1–5. Spot prices of Alabama coke ranged from $3.34 in the first part of 1913 (1) and a maximum of $3.45 for the years 1913–1915 in September, 1914 (2), to a minimum of $2.57 in March, 1914 (3). The minimum spot price in 1915 was $2.65 in July (4), from which the price rose steadily to $3.49 in September, 1916 (5).

6. The market price for Alabama coke rose rapidly from November, 1917, to a maximum of $8.27 in August and September, 1917 (6).

7. Prices fixed by the Government in November are shown at (7).

8. Substantial increases in the prices of coke allowed by the Fuel Administrator in the Black Creek, Brookwood, and Blue Creek districts on January 29, 1918, and in other portions of the field on February 15, raised the general average in February from $6.06 to $6.92 (8).

9. Subsequent changes in prices of Alabama coke allowed by the Fuel Administrator raised the general average by the end of 1918 to $7.46 (9).

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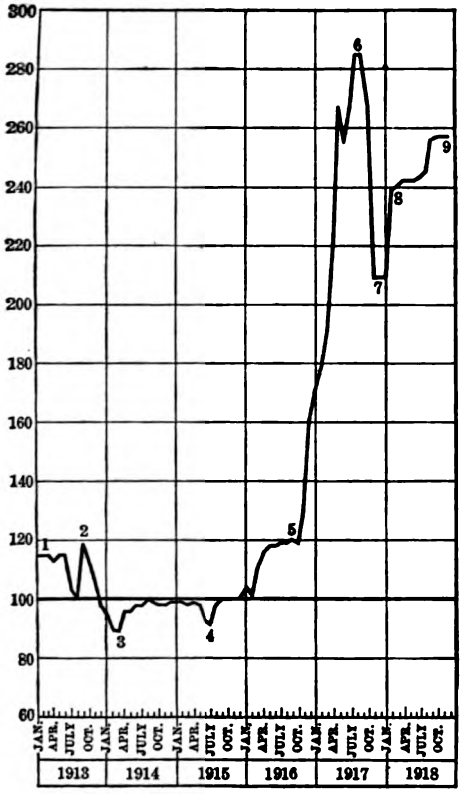

FIGURE 51.—Relative spot prices of coke produced in the Birmingham district, Ala., by months, 1913–1918.

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SALT, BROMINE, AND CALCIUM CHLORIDE.

By R. W. STONE.[1]

SALT.

PRODUCTION AND TRADE CONDITIONS.

The quantity of salt produced and sold in the United States in 1918 was 7,238,744 short tons, valued at $26,940,361, an increase of 3.7 per cent in quantity and 35.1 per cent in value over the production in 1917.

The values given in the tables in this report do not include the value of cooperage or containers.

Salt produced and marketed in the United States, 1913–1918.

Year.	Quantity.				Total value.	Average price per ton.
	Manufactured (evaporated) (short tons).	In brine (short tons).	Rock salt (short tons).	Total (short tons).		
1913	2,131,229	1,622,382	1,062,291	4,815,902	$10,123,139	$2.10
1914	2,159,094	1,652,758	1,060,804	4,872,656	10,197,417	2.09
1915	2,335,823	1,851,190	1,165,387	5,352,409	11,747,686	2.19
1916	2,454,836	2,539,717	1,368,353	6,362,906	13,645,947	2.14
1917	2,482,564	2,890,588	1,605,025	6,978,177	19,940,442	2.86
1918	2,724,203	2,830,600	1,683,941	7,238,744	26,940,361	3.72

The figures in this table show that the increase in the production of manufactured or evaporated salt in 1918 as compared with 1917 was 9.7 per cent and of rock salt 4.9 per cent. The production of brine salt decreased 2 per cent. The average price of all salt produced increased 30 per cent and was $3.72 a ton in 1918 as compared with $2.86 in 1917. This increase in price is a little less than the increase in 1917, which was 33 per cent, but was caused by the same things—higher wages and higher cost of fuel and other supplies.

There was a distinct shortage of labor in some localities in 1918, and the closing of factories on Mondays by the Fuel Administration for a few weeks early in the year caused some reduction in the quantity of salt produced. In general the demand for salt was good, orders being easily obtained, but the high and rapidly increasing cost of materials and the difficulty of getting help made it hard for some

[1] The statistical part of this report is the work of Miss M. S. Lundborg for domestic material and of J. A. Dorsey for imports and exports.

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producers to fill their orders. Producers in New York reported labor high and scarce and costs greatly increased but an advance in price disproportionately low. In Michigan one operator reported no change from 1917 in operating expense but others reported the cost of operation increased from 50 to 60 per cent. One operator in Kansas reported the cost about double that in 1916, except overhead charges, which had increased 25 per cent, and one producer in Texas reported the cost of fuel, labor, and containers as advanced much more than the prices received for salt. The Utah producers agreed that the demand was about the same as in 1917 and the prices remained practically stationary, but the cost of operating increased from 30 to 75 per cent. California producers reported the cost of labor practically double that of 1917, and one operator stated that it was impossible to get labor at any price. In the San Diego district the cost of producing increased according to one producer 25 to 30 per cent and according to another, 50 per cent, and prices increased in proportion. In the San Francisco Bay district there was some loss of salt on account of the heavy rain on September 12, which diluted the pickle and resulted in a considerable injury or loss to the crop. It is the general opinion that the cost of sacks in California increased about 300 per cent and that this was one of the principal reasons for the rise in prices. One producer stated that although the prices were raised considerably the profits were less than formerly. In Porto Rico one operator reported the market dull from lack of shipping and an increase of about 50 per cent in cost of labor and of 300 per cent in cost of packing, but the selling price of the salt remained unchanged.

The Morris Co., at Little River, Rice County, Kans., reported its plant completed and the shipment of salt begun on September 23, 1918. Benners Salt Co. (Inc.), New Orleans, La., reported its plant at Anse la Butte, St. Martin Parish, in course of construction and the expectation to have the product on the market by the summer of 1919. The Roessler & Hasslacher Chemical Co reported production for the first time from a plant at St. Albans, Kanawha Country, W. Va.

PRODUCTION BY STATES.

In 1918 the leading States in total quantity of salt produced were Michigan, New York, and Ohio. The number of operating plants in the principal States was California 22, Michigan 25, New York 17, Kansas 11, Ohio 12, and other States from 1 to 5 each, a total of 102 plants as compared with 125 plants in 1917.

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Salt produced and marketed in the United States, 1915–1918.

State.	1915		1916		1917		1918	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Michigan	1,762,430	$4,304,731	2,088,559	$4,612,567	2,250,939	$6,877,202	2,403,125	$9,048,650
New York	1,570,446	2,976,405	1,972,285	3,698,798	2,164,069	5,371,713	2,130,530	7,336,867
Ohio	823,234	1,462,192	938,867	2,038,749	1,026,803	2,839,575	1,069,887	3,273,390
Kansas	527,123	1,035,879	639,071	1,302,359	746,976	2,027,466	819,504	3,598,289
California	146,784	694,070	157,393	656,975	215,154	933,429	204,957	1,167,777
Texas	62,297	345,944	75,762	427,119	85,181	564,029	79,657	762,006
Utah	55,279	266,334	60,653	289,457	79,195	352,145	94,204	580,375
West Virginia	32,513	115,143	33,389	122,669	24,844	191,044	26,077	251,668
Idaho	(a)	(a)	44	511	16	216	(a)	(a)
Nevada	970	3,950	(a)	(a)	(a)	(a)	970	4,175
Other States	[b] 371,333	543,038	[c] 396,883	496,743	[d] 385,000	783,623	[b] 389,833	917,164
	5,352,409	11,747,686	6,362,906	13,645,947	6,978,177	19,940,442	7,238,744	26,940,361

[a] Included in "Other States."
[b] Includes Hawaii, Idaho, Louisiana, New Mexico, Oklahoma, Porto Rico, and Virginia.
[c] Includes Hawaii, Louisiana, Nevada, New Mexico, Oklahoma, Porto Rico, and Virginia.
[d] Includes Hawaii, Louisiana, Nevada, New Mexico, Oklahoma, Pennsylvania, Porto Rico, and Virginia.

ROCK SALT.

Large quantities of rock salt are mined in New York, Michigan, Kansas, and Louisiana from beds several hundred feet below the surface. In the arid regions of the West rock salt is taken from deposits at or near the surface. Idaho, Nevada, Utah, and California produce small quantities of this salt. Large quantities are available in these States, but there is little demand.

Rock salt produced and marketed in the United States,[a] 1914–1918.

Year.	Quantity (short tons).	Value.	Average price per ton.
1914	1,060,804	$2,024,898	$1.91
1915	1,165,387	2,299,894	1.97
1916	1,368,353	2,665,270	1.95
1917	1,605,025	3,897,595	2.43
1918	1,683,941	5,684,661	3.38

[a] California, Kansas, Louisiana, Michigan, New York, and Utah; in 1916 Idaho also; in 1917 Nevada also; in 1918 Idaho and Nevada also.

This table shows an increase in 1918 of 4.9 per cent in quantity and 45.8 per cent in value over the production of 1917, as compared with an increase of 17.3 per cent in quantity and 46.2 per cent in value in 1917 over the production of 1916.

New York is by far the largest producer of rock salt, its output being more than double that of Kansas, the next largest producer. Louisiana comes third and Michigan fourth, but the production of these two States was only a little more in 1918 than the output of Kansas. It is not possible to publish State totals for rock salt without revealing individual output, because in most States there are only one or two producers. Rock salt is mined by 19 producers in 8 States.

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BRINE SALT.

The various grades of salt produced by evaporating natural and artificial brine are put on the market under different names, according to use, size of grain, or method of preparation.

Brine salt produced and marketed in the United States, 1914–1918.

Year.	Table and dairy.		Packers' salt.			
			Common fine.		Common coarse.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
1914	577,020	$3,221,007	873,301	$2,383,588	530,483	$1,453,484
1915	607,749	3,720,020	981,829	2,762,450	536,774	1,724,503
1916	654,601	4,326,531	1,048,032	3,314,795	567,985	1,958,094
1917	688,022	5,908,788	1,048,572	5,311,668	493,515	2,659,013
1918	804,482	7,336,667	1,072,331	7,024,631	541,329	3,689,807

Year.	Coarse solar.		Pressed blocks and other grades.		In brine.		Total.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons)	Value.	Quantity (short tons)	Value.
1914	151,228	$451,206	27,062	$73,715	1,652,758	$589,519	3,811,852	$8,172,519
1915	162,569	508,402	46,902	130,452	1,851,199	601,965	4,187,022	9,447,792
1916	116,913	339,079	67,305	210,337	2,539,717	831,841	4,994,553	10,980,677
1917	159,361	524,987	93,094	554,805	2,890,588	1,083,586	5,373,152	16,042,847
1918	191,260	903,669	114,801	1,055,661	2,830,600	1,245,265	5,554,803	21,255,700

From the preceding table the following percentages have been determined:

Increase or decrease in brine salt produced in 1918 compared with 1917.

	Quantity (per cent).	Value (per cent).
Table and dairy	+16.9	+24.2
Common fine	+ 2.2	+32.2
Common coarse	+ 9.7	+38.7
Coarse solar	+20.0	+71.9
Pressed blocks, etc	+23.3	+90.4
Brine	− 2.1	+14.9

The only decrease in production was in the salt in brine, which fell off 2.1 per cent in quantity but increased 14.9 per cent in value. It is particularly conspicuous that the increases in value are very much larger than the increases in quantity. The increase of 20 per cent in quantity of solar salt produced indicates that in general weather conditions were favorable for solar evaporation. The demand for pressed blocks for salting cattle is increasing. The total quantity produced was 94,150 tons, valued at $939,900. This gives an average value per ton of $9.98. Kansas was by far the largest producer, with an output of 55,611 tons, valued at $498,099, as compared with Michigan, the second largest producer, which made an output of 19,362 tons, valued

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at $192,376. The other States producing pressed block are, in order of quantity produced, Texas, Utah, Ohio, and California. Salt not classified and included in "other grades" amounted to 20,651 tons, valued at $115,761.

The quantity and value of salt in brine used by chemical works showed for the first time in a number of years a decrease in the quantity used. The products made by chemical companies from nearly 3,000,000 tons of brine salt include salt cake, soda ash, caustic soda, sodium carbonate, sodium acetate, sodium chlorate, sodium phosphate, sodium silicate, sal soda, Glauber's salt, calcium chloride, chlorine, and hydrochloric acid.

Without including the salt in brine sold as such or used by chemical works, the evaporated salt was produced in the States and in the quantities shown in the following table:

Evaporated salt produced and marketed in the United States in 1917 and 1918.

State.	1917		1918	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.
California	192,565	$902,753	202,607	$1,154,852
Kansas	299,877	1,449,442	347,255	2,665,330
Michigan	891,195	5,859,594	1,059,872	7,926,745
Nevada	(a)	(a)	545	2,900
New York	517,273	3,077,910	521,568	3,871,887
Ohio	386,803	2,527,432	389,887	2,773,390
Texas	85,181	564,029	79,657	762,006
Utah	73,282	337,102	88,067	558,838
West Virginia	24,844	191,044	26,077	251,668
Other States b	11,544	49,955	8,668	42,819
	2,482,564	14,959,261	2,724,203	20,010,435
Percentage of increase in 1918			9.6	33.7

a Included in "Other States."
b Hawaii, Idaho, New Mexico, Oklahoma, and Porto Rico in 1918, with the addition of Pennsylvania in 1917.

AVERAGE PRICE.

The average price per ton of all grades of salt produced and marketed in the United States, as shown in the table on page 117, advanced from $2.86 in 1917 to $3.72 in 1918. Rock salt commonly is cheaper than evaporated or brine salt, and the price of each differs in different localities by reason of a variety of factors, among which supply and demand are potent. The following table shows some anomalous variations in price from year to year in certain States, but a general tendency toward higher prices is noticeable, especially in the last two years, and is most apparent in the averages given at the bottom of the table. The averages for the United States are computed from the quantity and value of the entire production for the year indicated and not from the State averages in the respective columns above them.

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Average price per ton of domestic salt, 1914–1918.

State.	Rock salt.					Brine salt.				
	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918
California	$7.00	$3.98	$2.99	$4.21	$5.50	$5.08	$4.73	$4.20	$4.34	$5.69
Hawaii	.....	.....	.....	.....	.....	.....	8.00	7.00	15.00	18.00
Idaho	.....	.....	10.00	10.00	10.00	12.38	10.00	15.00	15.60	18.00
Kansas	1.29	1.34	1.35	1.66	2.53	3.24	2.55	2.61	3.63	5.91
Louisiana	2.29	2.52	2.28	3.37	3.67	.....	.....	.....	.....	.....
Michigan	2.56	2.02	2.60	2.92	3.63	1.99	2.43	2.18	3.06	3.78
Nevada	.....	.....	.....	3.00	3.00	3.94	4.07	4.35	3.18	5.32
New Mexico	.....	.....	.....	.....	.....	7.00	2.76	2.00	2.41	10.00
New York	1.91	1.95	1.98	2.41	3.59	1.96	1.86	1.81	2.52	3.33
Ohio	.....	.....	.....	.....	.....	1.72	1.78	2.17	2.77	3.00
Oklahoma	.....	.....	.....	.....	.....	3.69	6.91	6.22	6.61	4.74
Pennsylvania	.....	.....	.....	.....	.....	5.25	.....	.....	3.00	.....
Porto Rico	.....	.....	.....	.....	.....	2.89	2.57	2.62	4.24	4.00
Texas	.....	.....	.....	.....	.....	5.36	5.55	5.46	6.62	9.56
Utah	2.81	2.29	2.24	2.54	3.50	4.61	5.04	4.99	4.60	6.35
West Virginia	.....	.....	.....	.....	.....	3.83	3.54	3.67	7.69	9.65
Average for the United States	1.91	1.97	1.95	2.43	3.38	2.14	2.26	2.62	2.99	3.83

From this table it is determined that the average price per ton of rock salt, $3.38 in 1918, increased 39.1 per cent over the average price for 1917, as compared with an increase of 24.6 per cent in that year over 1916. Likewise the average price per ton of brine salt, $3.83 in 1918, was an increase of 28.1 per cent over the average price in 1917, as compared with an increase of 14.1 per cent in that year over 1916.

DOMESTIC CONSUMPTION.

On the assumption that the population of the United States is 100,000,000, the quantity of salt used in this country in 1918 amounted to about 143 pounds, or a little more than half a barrel, per capita. The following table shows that very nearly all the salt used in the United States in 1918 was of domestic origin and that the percentage of imports to domestic consumption was less than ever before. Part of our domestic production was exported, but the exports were partly offset by imports, which were 0.6 per cent of the total consumption.

Supply of salt for domestic consumption, 1900–1918, in short tons.

Source.	1900	1910	1915	1916	1917	1918
Domestic production	2,921,708	4,242,792	5,352,409	6,362,906	6,978,177	7,238,744
Imports	199,909	137,103	122,326	122,079	64,922	40,290
Total	3,121,617	4,379,895	5,474,735	6,484,985	7,043,099	7,279,034
Exports	7,511	49,013	80,474	84,065	113,993	136,783
Domestic consumption	3,114,106	4,330,882	5,394,261	6,400,920	6,929,106	7,142,251
Comparison with preceding year	+178,449	+6,444	+473,096	+1,006,659	+528,186	+213,145
Percentage of imports to total consumption	6.4	3.2	2.3	1.9	0.9	0.6

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IMPORTS.

According to figures obtained from the Bureau of Foreign and Domestic Commerce, Department of Commerce, and after conversion from pounds as reported by that bureau to short tons, the salt imported and entered for consumption in the United States in the last five years is as follows:

Salt imported and entered for consumption in the United States, 1914–1918.

Year.	In bags, barrels, and other packages.		In bulk.		Total quantity (short tons).	Total value.
	Quantity (short tons).	Value.	Quantity (short tons).	Value.		
1914	32,807	$212,349	97,997	$168,454	130,804	$380,803
1915	28,724	196,593	93,602	169,859	122,326	366,452
1916	24,402	200,290	97,677	142,298	122,079	342,588
1917	13,472	139,339	51,450	140,796	64,922	280,135
1918	10,259	148,128	30,031	133,340	40,290	281,468

The source of the imported salt is shown in the following table:

Salt imported into the United States, 1916–1918.

[General imports.]

Country.	1916		1917		1918	
	Quantity (pounds).	Value.	Quantity (pounds).	Value.	Quantity (pounds).	Value.
Germany						
Italy	11,456,800	$8,028				
Portugal			3,724,600	$7,651	112,000	$216
Spain	68,740,200	35,243	7,342,000	5,209	10,180,000	6,750
England	59,372,500	219,351	34,960,600	164,624	34,102,700	219,007
Canada	16,744,700	17,844	5,718,000	18,734	589,200	6,663
Mexico	105,000	684	956,800	823	76,500	614
Barbados	140,000	140				
Trinidad and Tobago						
Other British West Indies	81,388,200	55,257	65,859,900	72,621	25,779,400	35,815
Cuba					103,800	134
Dutch West Indies	5,748,900	5,865	13,102,900	10,459	4,731,400	8,779
French West Indies					200,000	425
Dominican Republic					3,858,000	4,824
China			15,200	14		
Japan					200	5
Hongkong	200	6				
Portuguese Africa	237,400	170			896,000	800
	243,933,900	342,588	131,680,000	280,135	80,629,200	284,032

A large part of the imported salt is coarse solar salt made by evaporating sea water and comes from the West Indies and Spain. This cheap material enters the United States at a low freight rate and is used largely for curing fish and meats. The importation of salt from England is largely to supply packers who think they can not get satisfactory results without Liverpool salt.

The slight discrepancy between the number of pounds imported as shown in this table and the number of tons in the second table above is explained by the fact that some of the salt imported was in warehouse at the close of the year and had not been entered for consumption.

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EXPORTS.

The exports of salt in 1918 were 20 per cent greater in quantity and more than 67 per cent greater in value than in 1917. They were greater than ever before and were sent to all parts of the world. The accompanying tables were made from figures obtained from the Bureau of Foreign and Domestic Commerce.

Salt of domestic production exported from the United States, 1914–1918.

Year.	Quantity.		Value.
	Pounds.	Equivalent in short tons.	
1914	164,589,012	82,295	$586,055
1915	160,948,077	80,474	613,847
1916	168,129,201	84,065	567,441
1917	227,985,222	113,993	1,000,773
1918	273,565,496	136,783	1,677,577

Salt exported from the United States in 1916, 1917, and 1918.

Country.	1916		1917		1918	
	Quantity (pounds).	Value.	Quantity (pounds.)	Value.	Quantity (pounds).	Value.
Europe:						
Belgium						
Denmark	54	$2				
France	32,760	370	14,181	$187	10,000	$150
Greece						
Iceland and Faroe Islands	3,000	24	9,245	119	51,284	2,031
Italy			600	4	4,400	67
Netherlands						
Norway	2,983	65	950	18	2,100	84
Portugal	375	5				
Russia in Europe	251,628	1,443	179,648	1,360	27,714	241
Serbia and Montenegro, etc						
Spain						
Sweden						
Switzerland					26,000	390
United Kingdom:						
England	286,458	5,247	7,572	160	56,694	406
Scotland						
Ireland	560	5				
North America:						
Bermuda	312,190	2,868	367,582	3,733	295,650	2,909
British Honduras	542,309	2,579	699,601	2,861	611,722	4,598
Canada	112,072,308	274,146	141,977,910	474,810	160,360,923	617,907
Central American States:						
Costa Rica	554,556	3,771	358,070	3,148	240,819	4,200
Guatemala	335,861	1,870	136,640	1,222	173,521	1,876
Honduras	760,638	4,147	1,774,138	9,810	2,159,241	16,892
Nicaragua	458,055	3,989	853,841	7,473	557,894	6,883
Panama	3,064,625	18,574	4,126,157	20,267	5,881,821	49,707
Salvador	10,621	113	504	10	5,735	194
Mexico	4,457,377	36,380	11,157,848	76,038	6,958,031	78,554
Miquelon, Langley, etc	1,798	21	5,450	45	1,346	23
Newfoundland and Labrador	818,560	3,092	4,081,348	29,014	5,827,019	48,115
West Indies:						
Barbados	2,187	35	5,633	112	1,952	48
Jamaica	373,564	1,357	764,245	2,844	43,749	295
Trinidad and Tobago	4,520	39	3,200	39	3,105	88
Other British	19,505	249	19,446	322	15,262	428
Cuba	40,101,863	169,798	52,171,794	262,265	58,498,163	530,669
Danish (Virgin Islands)	4,062	62	155,152	876	3,957	100
Dominican Republic	130,007	1,555	134,563	2,424	572,821	5,320
Dutch West Indies	2,156	23	493	11	487	10
French West Indies	22,162	354	29,787	578	20,158	572
Haiti	6,613	110	12,301	216	12,989	430

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Salt exported from the United States in 1916, 1917, and 1918—Continued.

Country.	1916		1917		1918	
	Quantity (pounds).	Value.	Quantity (pounds).	Value.	Quantity (pounds).	Value.
South America:						
Argentina	105,616	$889	91,093	$626	26,140	$1,015
Bolivia	2,400	31	.....	.....	320	9
Brazil	33,569	344	18,455	283	7,946	127
Chile	313,303	1,816	32,356	435	27,044	452
Colombia	285,356	1,458	287,655	2,959	189,362	2,698
Ecuador	240	12	50	2	.....	.....
Guiana:						
British	116,588	691	366,124	5,741	18,453	334
Dutch	2,713	58	16,632	173	6,010	132
French	1,560	23	5,650	48	17,000	198
Paraguay	1,800	47	.....	.....	14,000	175
Peru	43,190	346	68,123	657	.....	.....
Uruguay	.....	.....	162	4	.....	.....
Venezuela	2,796	39	6,724	116	.....	.....
Asia:						
China	3,460	57	8,227	302	28,175	1,710
Japanese China	.....	.....	.....	.....	74	6
Chosen	7,917	77	11,475	185	5,819	225
East Indies:						
British:						
British India	934	24	7,319	126	42,269	2,975
Straits Settlements	.....	.....	2,850	132	7,345	439
Other British	.....	.....	1,484	28	11,882	755
Dutch	3,168	70	47,220	1,786	498,712	17,783
French	.....	.....	.....	.....	6,979	283
Hongkong	5,050	178	20,267	831	7,077	467
Japan	50,250	137	1,835,454	12,291	2,418,230	13,369
Russia in Asia	1,240	10	40	2	70	2
Siam	.....	.....	2,640	106	7,586	233
Turkey in Asia	.....	.....	.....	.....	.....	.....
Oceania:						
British:						
Australia	626,550	10,417	2,604,029	35,637	3,992,560	50,988
New Zealand	1,438,411	11,575	3,017,167	20,309	22,931,065	192,988
Other British	6,450	105	6,516	143	34,748	494
French Oceania	229,025	1,867	198,613	2,208	537,074	7,109
German Oceania	9,550	137	31,886	435	53,914	869
Philippines	185,860	4,507	231,239	5,735	222,679	7,760
Africa:						
Belgian Kongo	100	2	723	12	7,876	143
British Africa:						
West	.....	.....	4,001	166	17,522	567
South	17,190	216	6,600	128	124	2
East	.....	.....	5,200	118	1,200	40
Canary Islands	.....	.....	.....	.....	.....	.....
Egypt	.....	.....	.....	.....	.....	.....
French Africa	1,400	14	112	4	100	3
Liberia	100	1	1,160	16	520	19
Madagascar	.....	.....	.....	.....	.....	.....
Portuguese Africa	.....	.....	72	3	1,004	21
	168,129,201	567,441	227,985,222	1,000,773	273,565,496	1,677,577

According to the preceding table more than one-half of the salt exported from the United States goes to Canada. The quantity sent to Canada is increasing steadily and the 160,360,923 pounds, or 80,180 short tons, exported to Canada in 1918 was more than double the quantity exported in 1915. Cuba is the next largest consumer, having taken 58,498,163 pounds, or about 29,250 short tons, in 1918. The most notable increase among the larger importers of salt from the United States is New Zealand, which took 720 tons in 1916 and 11,465 tons in 1918. Mexico and Panama were the next largest consumers of United States salt in 1918. South American countries took comparatively little, they being supplied more largely from England.

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DOMESTIC DEPOSITS.

The salt deposits in the United States are fully described in United States Geological Survey Bulletin 669, "The salt resources of the United States," by W. C. Phalen. This illustrated bulletin of 285 pages was issued in May, 1919, and may be obtained free of charge on application to the Director, United States Geological Survey, Washington, D.C. It contains descriptions of the deposits, arranged by States, a discussion of the origin and formation of saline deposits, many analyses of rock salt, brines, and bitterns, and statistics of the production of salt since the beginning of the industry.

FOREIGN DEPOSITS.

In view of the recent need for information on the mineral resources of other countries, the following summary of distribution of salt throughout the world has been prepared.

NORTH AMERICA.

Canada.—In Canada practically the only producing Province is Ontario. Along the eastern shore of Lake Huron are rock salt beds about 1,000 feet below the surface and 14 to 252 feet thick. Salt is recovered by drilling wells and filling them with water, thus dissolving the salt, which is pumped up in the form of brine, and then evaporated and prepared for market.

Canada produced 131,727 tons of salt in 1918 and imported about 80,180 tons from the United States as well as a considerable quantity from England. About 300 tons of salt was shipped from Canada to the United States in 1918, a great decrease from the 8,000 to 10,000 formerly shipped annually to this country.

A deposit of rock salt is being developed neat Malagooh, Cumberland County, Nova Scotia. This is the first rock salt discovered in Canada that can be reached by a shaft of moderate depth.

Mexico.—High-grade salt for table use in Mexico is mostly imported from the United States and England. Exports to Mexico from this country have ranged in the last five years from 2,200 to 7,500 tons in a year. Domestic production supplies a large part of the salt consumed but much of the domestic material is not refined. It is derived in large part from the solar evaporation of sea water and to a less extent from mines.

Central America.—Only a small quantity of salt is made in the countries of Central America, much of the demand being supplied by importation from England and the United States. Exports to these countries from the United States amount to 3,000 to 4,000 tons annually, most of which goes to Panama. Most of the native salt is made by solar evaporation of sea water along the Pacific coast and the Gulf of Mexico. Besides these sources of production salt is obtained also from mines, as the salt mines in the departments of Huehuetenango and Verapaz, Guatemala.

West Indies.—Salt is produced by solar evaporation of sea water at a number of places in the West Indies. Turks Island, the easternmost of the Bahama Islands, and lying north of Haiti, is the largest producer in the region. Turks Island sea salt reaches the

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United Stated in quantities of several thousand tons annually and is used largely for salting fish and meat. The United States ships about 25,000 tons of salt annually to Cuba.

SOUTH AMERICA.

In South America solar salt is produced by the evaporation of sea water in Argentina, Brazil, Venezuela, and other countries, and rock salt is mined in Chile and Colombia. Much of the coarse salt used in South America is imported from Spain, and fine salt from England.

The following notes on salt in South America are quoted from "Mineral deposits of South America," by B. L. Miller and J. T. Singewald, 1919:

Argentina.—The prevailingly arid climate of so much of Argentina and the numerous depressions without outlets result in the presence of many saline lakes, which serve as the sources of the local salt supply. In the southern part of the Province of Buenos Aires is a saline lake the water of which is transported by the South American Salt & Chemical Production Co. (Ltd.) in a 4-inch pipe line to works on the Bay of San Blas, where it is evaporated and yields a salt containing 97 per cent sodium chloride. On the peninsula of Valdez, in Chubut, are two saline lakes which, through the evaporation of the waters in the dry season, contain large quantities of high-grade salt along their margins. A railway has been built to the coast to facilitate shipments. Considerable salt for local use is also produced by solar evaporation of the waters of Lake Bebedero near the city of San Luis.

Brazil.—A large part of the salt consumed in Brazil is imported, although the country is not entirely lacking in salt deposits.

Rock salt is said to have been mined in limited quantities in Matto Grosso and Goyaz. Considerable salt is obtained in the States of Rio Grande do Norte, Alagoas, Sergipe, Ceara, Piauhy, and Rio de Janeiro through the evaporation of ocean water of partially inclosed lagoons.

In the Sao Francisco River valley in Bahia considerable salt is obtained by leaching the surface soils where small ponds have disappeared by evaporation. Naturally such salt contains impurities, as does that obtained from ocean waters.

Chile.—Vast deposits of salt are found widely distributed throughout the arid portion of northern Chile in the salares, which represent desiccated lakes or salt deposits formed by the evaporation of the ascending shallow ground waters. Nevertheless, up to 1902 the country imported a large part of its salt supply. Since then, however, it has entered the export field itself. This is largely the result of the building of an aerial tramway from the Salar Grande, which lies in the southern part of the Province of Tarapaca and about 11 miles inland, to the port of Caleta Pescadores. The Salar Grande covers about 80,000 acres and contains practically pure sodium chloride in enormous quantities. Much of it analyzed 99.99 per cent pure. The thickness of the deposit is not known, but a shaft 82 feet in depth failed to reach the underlying rock stratum.

Although the single deposit at Salar Grande could easily supply the entire country, and the world besides, yet on account of the high cost of transportation many other deposits are worked on a smaller scale to supply the immediate vicinity.

Throughout the western part of the Province of Tarapaca the lowest portions of the salares are covered with thick layers of common salt. These salares present an interesting appearance with their glistening white salt crystals. The surface is not flat, but, instead, everywhere roughened by hummocks or fissured compression ridges up to 3 feet in height. Where railroads cross the salares the track is very rough, owing probably to changes in the surface produced by upheaval as the result of growing crystals obtaining new supplies of material from the ascending ground water.

In a salar near Lagunas, salt is obtained in a unique manner. Ditches are cut in the surface of the salar to a depth of 8 inches below the level of ground water, which here lies at a depth of 3 to 3½ feet. The ditches, exposed to the hot, dry sunshine and parched winds, act as very efficient evaporating pans, and the saline water underlying the salar, exposed in the ditches, is evaporated to the point of saturation when salt begins to crystallize. Since the level of ground water is maintained in the ditches by the constant seeping in of the ground water, the salt continues to accumulate until it reaches the height of ground water, or a thickness of 8 inches, when the ditch has dried up. The salt is shoveled out by hand, and as it is removed the

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water again comes in. After a ditch has its salt removed, the same process is gone through again. The rate at which the salt forms is 1 inch in 15 days, or at the rate of three crops of salt a year.

The salt is shoveled out on the ground between the ditches to drain and dry and is then packed in sacks holding 2 quintals each, or about 200 pounds. Most of it is of a beautiful snowy white color and pure enough for table use. Occasionally, however the violent wind storms which sweep across the pampa blow enough of the yellow pampa dust into the ditches to give the salt a dirty color. Such salt is kept separate from the rest and sold for cheaper uses. A branch of the Nitrate Railways to the South Lagunas Nitrate Oficina runs between the salt ditches and affords very convenient shipping facilities.

This salt industry was established on a very small scale about 10 years ago and has proved to be such an inexpensive method that it has grown rapidly, until now there are 150 of these evaporating ditches. Each ditch covers an area ranging about 40 by 40 by 100 feet. The output is about 16,000 quintals a month, which is roughly equivalent to about 10,000 tons annually.

Colombia.—The salt industry is a government monopoly in Colombia, and all salt deposits and saline springs whose waters exceed 6 per cent in saturation are its property. There are three commercial sources of salt, which, arranged in the order of their importance, are:

1. Rock salt found in the Cretaceous or Tertiary beds east of Magdalena River in the Departments of Cundinamarca and Boyaca and the Intendencia del Meta. The most important of these localities is Zipaquira. Others producing salt are Nemocon, Tausa, and Sesquile in Cundinamarca, and Cumaral and Upin in Meta. The deposits are worked either as rock salt or by leaching and evaporation of the concentrated brines. The Zipaquira occurrence consists of a small hill about 2 kilometers in diameter and 250 meters high at the western edge of the town. The salt was worked in an open cut at the summit by the Chibchas before the Spaniards came, but in later years underground mining has been used. González Benito and Davison have calculated the available tonnage at 1,000,000,000. Armenta gives the annual production at 20,000 tons, costing $150,000 and producing for the government a profit of over $350,000. The composition of the salt is stated to be similar to that of sea salt.

2. Salt derived from solar evaporation of sea water along the Caribbean coast. The production from this source is given at 6,000 tons annually.

3. Salt produced from saline springs west of the Magdalena River, where transportation difficulties make the cost of salt from the other two sources excessive. The annual production from this source 10 years ago was about 3,000 tons, but this is decreasing as improved transportation facilities make other salt more readily obtainable because much of it is of inferior quality, containing such salts as sodium sulphate, magnesium sulphate, and sodium bicarbonate in large quantity. The saline springs whose waters are utilized for salt production are located in the Departments of Antioquia, Caldas, Cauca, Narino, and Huila.

Ecuador.—Salt is a government monopoly and is produced in quantity sufficient for domestic use with a small amount for exportation to Colombia.

The greater part of the Ecuadorean salt output comes from the Santa Elena region, where it is produced by solar evaporation. Saline springs yield salt in the Province of Carchi at Mira and Salinas. At Mira the evaporation of saline ground water resulting from saline springs issuing from the underlying trachyte impregnates the sandy soil with salt to a depth of several inches. This sand is collected and the salt washed from it. At Salinas the saline spring waters are evaporated directly for the salt. That obtained from these two localities contains iodine.

Peru.—The salt industry is a government monopoly that maintains a nearly uniform production in the neighborhood of 25,000 tons.

The salt industry is under the control of the Compañía Salinera Nacional, supervised by the government. The production comes from salares along the coast, beds of rock salt, and the evaporation of saline spring water. South of Sechura, in Piura, is a depression into which Piura River overflows in the rainy season. It has leached the saline ground over which it flows, and salt is deposited upon the evaporation of the water in the depression. The Salinas de Morrope in Lambayeque contain a layer of salt from a few to 50 or 60 centimeters in thickness, covered by at least 20 centimeters of sand, over an area 10 kilometers long and 6 kilometers wide. At Guadalupito, Libertad, is a saline marsh of ground water moving toward the sea. Salt accumulates in ditches cut in the marsh through evaporation by sun and wind. Other important producers of similar character to the preceding are the Salinas de Casma, Ancachs, and the Pampas de las Salinas near Playa Chica, Lima. The latter represent desiccated cut-off arms of the sea in which the quantity of salt has been augmented through the aid of ground water resulting from the condensation of fogs. The deposit is 2

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miles long, 1 mile wide, and in places several yards thick. It is taken out as rock salt of various degrees of purity according to depth, the purest at the bottom.

At San Blas, Junin, 8 to 10 meters of rock salt are being removed from a bed of unknown thickness. Rock salt is also mined at Cachi, in Huancavelica. At Maras, Cuzco, a stream of salt water, emitted from a mountain, flows down a gulch emptying into the Urubamba River. The water is evaporated in the dry season.

Venezuela.—Salt is one of the important mineral products, and as it is a Government monopoly it has been a source of great revenue to the country.

All of the salt occurs in salt pans in the arid portions, where lakes or arms of the ocean have disappeared by evaporation.

On the peninsula of Araya, opposite Cumana, there is an extensive deposit of practically pure sodium chloride which has been worked ever since the earliest settlement of the country. On the island of Coche, a short distance away, near Barcelona, at Sinamaica, in the northern part of the State of Zulia, and in the State of Falcon, salt deposits of less purity are also worked. Pits dug in the salt pans fill with salt water and on evaporation deposit the salt. The salt obtained from Coche Island is said to be of unusually high quality.

EUROPE.

United Kingdom.—In the United Kingdom the great center of the salt industry is Cheshire, England, where rock salt is mined from very considerable deposits. England not only supplies practically the whole need of the United Kingdom but exports 500,000 tons annually, a large part going to British India. A very small quantity of salt is made in Scotland by evaporating sea water, and in Ireland by evaporationg brine made by dissolving rock salt in sea water. Solar heat is insufficient to make evaporation from sea water alone profitable, so it is strengthened with rock salt and the brine is boiled.

England produces about 2,000,000 tons of salt annually and ships from 15,000 to 40,000 tons of Liverpool salt to the United States.

Central Empires.—Germany is a large producer of salt, the trade in which is largely a syndicate monopoly. The annual production is about 2,000,000 tons. Both rock and brine salt are produced and much of it is from Government-owned mines. The great salt mines at Stassfurt in north-central Germany and at Salzburg, Austria, have long been well known.

Austria and Hungary produce most of their salt from deep mines, which yield about 800,000 tons annually.

France.—Salt is mined in France, and also evaporated from sea water on the Mediterranean shore.

Greece.—Greece makes a considerable output of salt by evaporating sea water.

Italy.—Italy manufactures salt by solar evaporation of sea water, and partly under Government monopoly. Sicily and Sardinia are small producers.

In 1915 the United States imported 11,000 tons of Italian marine salt. This importation was cut off in 1917 and 1918.

Rumania.—In Rumania the domestic supply is obtained by the mining and treatment of rock salt; none by the evaporation of brine.

Switzerland.—In Switzerland salt mines are owned by the several Cantons and most of the domestic supply is obtained from this source.

Russia.—Russia is one of the richest salt-bearing countries of the world. The Donetz Basin is the largest producing area and Orenburg Province is the richest in salt in Russia. Of the domestic production, 500,000 tons, or one-fourth, is rock salt; 1,000,000 tons, or one-half, is from lake bottoms; and the remainder is produced by evaporation of brines from salt wells or deeply buried brines. Five

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great salt lakes on the western and southern frontiers of Kooban Province constitute an inexhaustible supply.

Russia's annual production is approximately 2,200,000 tons.

Spain.—Spain produces salt mainly by evaporation of sea water, but a small quantity is derived by mining rock salt. Practically all salt used is of domestic production. There are large deposits of rock salt as yet untouched. The United States imported 34,000 tons of sea salt from Spain in 1916 and 5,000 tons in 1918, most of which was used by fish and meat packers on the Atlantic coast.

Turkey.—Turkey produces and exports salt made by evaporation of ocean brine.

Other countries.—Belgium, Denmark, Norway, and Sweden are not producers of salt. It is stated, however (Commerce Records, October 12, 1918), that experiments in Norway for the extraction of salt from the ocean by electricity have been successful and that two plants will be started in the near future, one in western and one in northern Norway. Each factory is to make 50,000 tons a year. Domestic fisheries will furnish a market.

ASIA.

Aden.—One of the most favorably situated countries in the world for the production of salt by solar evaporation of sea water is Aden, bordering on the Gulf of Aden, south of Arabia. The sea water is said to be more dense than normal, the topography is ideal, and there are few days in the year when the sun does not shine with great heat and intensity. The annual output is about 150,000 tons, practically all of which is exported, principally to Calcutta, India.

China.—China must be a large producer of salt for its millions of inhabitants are dependent on domestic supply. For a great many years salt has been a government monopoly, yielding a large revenue, and importations have been forbidden or restricted. The annual output is estimated at 1,800,000 tons. Salt is produced by solar evaporation of sea water at the coast and of brine from wells and lakes inland, and also by evaporation of brine with artificial heat. There are many producing districts, from Shantung Province on the east to Szechuen Province in western China.

India.—There are four great sources of salt in India—rock salt from the Salt Range and Kohat mines in the Punjab; brine salt from the Sambhar Lake in Rajputana; salt brine condensed on the borders of the lesser Rann of Cutch; and sea-salt factories in Bombay, Madras, and at the mouth of the Indus. In Bengal the damp climate, together with the large volume of fresh water from the Ganges and the Brahmaputra into the Bay of Bengal, render the manufacture of sea salt difficult, and the bulk of the supply, both for Bengal and Burma, is imported from Liverpool, Aden, Egypt, Spain, Italian East Africa, Bombay, and Madras. Nearly every district of Burma is a salt producer. The Tenasserim coast produces 65 per cent and Moulmein more than 52 per cent of the total output. Burma's yield in 1916 was 42,225 tons. The local market is large, because of the extensive native fishing industry. In Southern India the salt industry of Madras Presidency is important and yields 400,000 to 500,000 tons annually. All the salt factories are on the eastern coast of the Presidency.

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The production of salt in India amounts to more than 1,000,000 tons annually and in favorable years has been about 1,400,000 tons.

Japan.—Japan produces about 95 per cent of her domestic consumption of salt. Solar evaporation of sea water is the method and source of the supply, and yields about 600,000 tons annually.

Japan imported 1,200 tons of salt from the United States in 1918.

Siam.—Siam, like Japan, derives its supply of salt almost entirely from the solar evaporation of sea water on mud flats along the coast.

AFRICA.

In the countries of northern Africa, most of the salt supply is of domestic origin and is derived from solar evaporation of sea water. In the Union of South Africa, a large part of the salt consumed is taken from shallow lakes or ponds fed by saline springs. There is no salt mining. In most other African countries all the salt that is used is imported.

OCEANIA.

Australia's chief domestic source of salt is in the States of South Australia and Victoria. There is, however, a large importation from England. New Zealand which does not produce salt draws her supply largely from England, but received 11,000 tons from the United States in 1918. It has recently been proposed to produce salt from sea water in New Zealand by the use of hydroelectric power.

In the Philippine Islands salt is now made by solar evaporation of sea water, and, although prior to 1913 much of the salt consumed by the Filipinos was imported from China, the imports are now greatly diminished.

BROMINE.

PRODUCTION.

The bromine marketed in 1918 increased 92.9 per cent in quantity and 96.9 per cent in value over the production in 1917. The marketed output of the last nine years is given in the following table:

Bromine produced and marketed in the United States, 1910–1918.

Year.	Quantity (pounds).	Value.	Average price per pound.
1910	245,437	$31,684	$0.13
1911	651,541	110,902	.17
1912	647,200	145,805	.22
1913	572,400	115,436	.20
1914	576,991	203,094	.35
1915	855,857	856,307	1.00
1916	728,520	951,932	1.31
1917	895,499	492,703	.55
1918	1,727,156	970,099	.56

The prices in the table are derived from the total quantity and value as reported to the Geological Survey by the producers and represent average prices for the year f. o. b. at the plants.

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The output in 1918, which was by far the largest in the history of the industry, was made as usual from bittern left after extracting salt from the brine pumped from deep wells at Midland and Saginaw in Michigan; at Pomeroy in Ohio; and at Mason, Hartford, and Malden in West Virginia. Several new wells were drilled near Midland, Mich., in the first half of 1918 to increase the supply of brine.

A large part of the output is not actually marketed as bromine but in the form of potassium and sodium bromide and other salts. The figures given include the bromine content of these salts.

During the first three months of 1918 four of the plants were idle because they were being rebuilt or were short of labor. The effect of this condition on the output and the increase when all plants were running are shown in the following table:

Production of bromine in the United States in 1918.

	Pounds.
First quarter	350,234
Second quarter	492,219
Third quarter	423,526
Fourth quarter	461,177
	1,727,156

Great Britain, France, and Italy were largely dependent on the United States for their supply of bromine in 1918 and large quantities were exported to them for medicinal and other purposes.

Bromine has not been imported into the United States for several years and exports of bromine are not separately reported by the Bureau of Foreign and Domestic Commerce.

PRICE.

The wholesale price of bulk bromine in New York was 25 to 35 cents a pound in 1913 but rose to 50 cents a pound soon after the war began. The increase in price through 1915 to the spring of 1916 and the steady decline since then is shown in the following table, which has been compiled from the Journal of Industrial and Engineering Chemistry. During 1918 the price remained steady at about 75 cents until the armistice was signed and the foreign demand fell off and was 50 cents at the end of the year.

Wholesale price per pound of bulk bromine in New York City, 1915–1918.

	1915	1916	1917	1918
January	$0.40–$0.50	$5.00–$6.50	$1.40–$1.50	$0.75–$0.85
February	.40– .50	5.00– 6.50	1.40– 1.50	.75– .85
March	.40– .50	5.00– 6.50	1.30– 1.40	.75– .85
April	.40– .50	Not quoted.	1.30– 1.40	.75– .85
May	.40– .50	4.75– 5.25	.80– 1.00	.75– .85
June	.85– .87	3.50	.85– 1.00	.75– .85
July	.85– .87	3.50	.55– .60	.75– .85
August	.85– .87	2.40– 2.50	.55– .60	.75–
September	1.00– 1.25	1.30– 1.40	.55– .60	.75–
October	1.25– 1.60	1.20– 1.30	.55– .60	.75–
November	1.50– 1.75	1.40– 1.50	.55– .60	.75–
December	1.50– 1.75	1.40– 1.50	.60– .65	.50–

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USES.

Bromine was used extensively in making asphyxiating gases employed in the European war, and after the armistice was signed the demand fell off. Its use in medicine for the treatment of nervous diseases likewise made an increased demand for this material during the war, but this demand still continues. A well-known and continuous use of bromine, both in war and peace, is its application in the form of bromide of silver to photography.

CALCIUM CHLORIDE.

PRODUCTION.

Large quantities of calcium chloride are produced in connection with the ammonia soda process at Solvay, N. Y., Wyandotte, Mich., Barberton and Fairport Harbor, Ohio, Hutchinson, Kans., and Saltville, Va.; but this material derives its calcium from limestone and its chlorine from common salt, and is not an original constituent of the brine pumped at these places. For this reason the calcium chloride so produced is not considered by the Geological Survey in its statistics. Only that calcium chloride which is an original constituent of natural brine and which is produced in connection with the manufacture of salt and bromine from such brine is here recorded. This material is interchangeable for most uses with the waste product of the ammonia soda process, but contains a notable percentage of magnesium. Analyses of calcium chloride obtained from natural brines show from 2 to 6 per cent of magnesium as an impurity. Calcium chloride containing magnesium was made in 1918 at Midland and Saginaw, Mich.; Pomeroy, Ohio; Mason, Hartford, and Malden, W. Va.; and Saltus, San Bernardino County, Calif.

The following table shows a decrease of 12.7 per cent in quantity and an increase of 11.5 per cent in value of calcium-magnesium chloride in 1918:

Calcium-magnesium chloride produced and marketed in the United States, 1910–1918.

Year.	Quantity (short tons).	Value.	Average price per ton.
1910	10,971	$74,713	$6.81
1911	14,606	91,215	6.25
1912	18,550	117,272	6.32
1913	19,611	130,030	6.63
1914	19,403	121,766	6.28
1915	20,535	130,830	6.37
1916	27,709	224,997	8.12
1917	30,503	451,480	14.80
1918	26,624	503,452	18.91

USES.

Calcium chloride is used for the prevention of dust on roads and playgrounds, in brine for refrigerating plants, for protection against fire, for the prevention of freezing, as a drying agent, and for some other purposes. Because of its strong affinity for water, sprinkling with calcium chloride will keep a road moist and therefore dustless

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for several weeks. A calcium-chloride solution has some advantage over salt brine in refrigerating machinery for ice factories, meat-packing houses, and cold-storage warehouses. A solution of calcium chloride in fire buckets has an advantage over water in that it does not corrode metal, has a lower freezing point, and because of its affinity for water tends to keep the buckets full by extracting moisture from the air. For this same reason it is used to dry gases, fruits, and vegetables.

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FULLER'S EARTH.

By JEFFERSON MIDDLETON.

GENERAL CONDITIONS.

There was remarkable activity in the fuller's earth industry in 1918. Domestic fuller's earth is used chiefly in refining petroleum, and, as a result of the increase in the production of petroleum, the quantity, value, and average price per ton of fuller's earth sold in 1918 were by far the largest ever recorded by the United States Geological Survey, the increase in quantity being 11,901 short tons, or 16 per cent, and in value $374,267, or 48 per cent, compared with 1917. Although the demand was good, the conditions of labor, fuel, and transportation tended to restrict the output. The imports, on the other hand, on account of the scarcity of bottoms and of the increase in ocean freights, declined 4,387 tons, or 26 per cent. The value of imported fuller's earth (reported as at the foreign port of shipment) decreased $10,882, or 6 per cent. The apparent consumption—production plus imports—increased from 89,561 short tons in 1917 to 97,075 tons in 1918, an increase of 7,514 tons, or 8 per cent. On this basis the domestic production formed 87 per cent of the consumption in 1918, against 81 per cent in 1917. Exports of fuller's earth, if any, were not separately classified.

The most promising development of the year was the utilization of a deposit of earth in Ash Meadows, Nye County, Nev., near Death Valley, Calif., which is reported to be very large. This material is known in the trade as "Death Valley clay," probably because it was first reported as coming from Death Valley, and is said to be excellent for filtering mineral oils.

The mineral advisers of the United States Shipping Board studied closely throughout the war the adequacy of available supplies of fuller's earth to meet war demands. On their recommendation the following regulations were issued by the War Trade Board April 22, 1918:

> No import licenses for shipments made after May 18, 1918, will be granted for fuller's earth except for shipments coming (*a*) overland or by lake from Canada; (*b*) overland from Mexico; (*c*) as return cargo from European countries, and then only when shipped from a convenient port and when loaded without undue delay.

On January 1, 1919, practically all restrictions on the imports of fuller's earth were removed by the following order:

> On and after January 1, 1919, licenses may be issued, when the applications therefor are otherwise in order, for the importation of fuller's earth from any primary or overseas market.

A complete embargo on imports of fuller's earth was not recommended, because it was believed that the domestic output available

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for refining edible oils was not sufficient to meet the demand and that it could not be made sufficient in the immediate future. The Shipping Board's inquiries also brought out the interesting information that only domestic fuller's earth is used for the refining of mineral oils. There appears, on the other hand, to be a difference of opinion as to the suitability of the domestic earth for use in refining edible oils. Some of the larger users of fuller's earth, anticipating a shortage of imported material, began early in the war to experiment with domestic earths in refining edible oils and fats, with results so satisfactory that they became independent of imported earth. Others stated that they had experimented with every known domestic earth, but had not found one that completely met the requirements to supplant the imported earth. The requirements of a good earth for refining edible oils are (1) that it shall bleach well and that the oil shall not revert to its original color; (2) that it shall filter well and not cake badly; (3) that it shall leave no permanent disagreeable taste or odor; (4) that the retention of oil in the spent earth shall be small; and (5) that there shall be no spontaneous ignition either in the press or in the waste piles. Those who use the imported earth claim that it is standard in all of these requirements, and that the domestic earth is deficient in one or more of them. Such a defect as inability to bleach well appears to be inherent in some domestic earth, and can not be remedied by treatment. Other defects, such as the taste or odor left by the earth, which is the most frequent objection urged against the domestic material, may possibly be overcome by treatment. Another serious fault charged against the American earth is that it retains a greater proportion of oil than the English earth, which means a direct loss in production; also that it clogs the filter presses more, so that they require more frequent cleaning, which causes further decrease in production. It is also charged that domestic earth is more subject to spontaneous combustion.

OCCURRENCE.

Fuller's earth has been reported in Alabama, Arizona, Arkansas, California, Colorado, Florida, Georgia, Massachusetts, Minnesota, Mississippi, Missouri, Nebraska, Nevada, New York, South Carolina, South Dakota, Texas, Utah, Virginia, and Washington; but it was produced in 1918 only in Alabama, Arkansas, California, Florida, Georgia, Massachusetts, Nevada, and Texas. These eight States, except Alabama and Nevada, were productive in 1917 also. Florida, Georgia, Alabama, Arkansas, and Texas produced 99 per cent of the domestic fuller's earth marketed in 1918.

USES.

Fuller's earth obtains its name from its original use in fulling cloth, but only a small quantity, mainly domestic, is now used in this country for that purpose. It is used principally in bleaching and in clarifying or filtering fats, greases, and oils. It is also used in the manufacture of pigments for printing wall papers, in detecting certain coloring matters in some food products, as a substitute for talcum powder,[1] and, in medicine, as a poultice and as an antidote for alkaloid poisons.

[1] Bur. Mines Bull. 71, p. 19, 1913.

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PRODUCTION.

The growth of the industry in the last 10 years and the production in 1917 and 1918 by groups of States are shown in the following tables. The rapid growth of the industry since 1912 is most gratifying. The output in 1918 was more than double and the value more than treble that of 1912. The output in 1918 was 12 times as great and the value 28 times as great as in 1895, the first year of commercial production in the United States. The lowest average price per ton ($5.72) was in 1904; the highest ($13.57) was in 1918; and it was $2.93 higher than in 1917.

Fuller's earth produced and marketed in the United States, 1909–1918.

Year.	Operators reporting sales.	Quantity (short tons).	Value.	Average price per ton.
1909	15	33,486	$301,604	$9.01
1910	17	32,822	293,709	8.95
1911	13	40,697	383,124	9.41
1912	13	32,715	305,522	9.34
1913	10	38,594	369,750	9.58
1914	14	40,981	403,646	9.85
1915	12	47,901	489,219	10.21
1916	10	67,822	706,951	10.42
1917	11	72,567	772,087	10.64
1918	14	84,468	1,146,354	13.57

Fuller's earth produced and marketed in the United States, 1917–18.

State.	1917				1918			
	Number of operators.	Quantity (short tons).	Value.	Average price per ton.	Number of operators.	Quantity (short tons).	Value.	Average price per ton.
Alabama,[a] Florida, Georgia, and Massachusetts	7	67,397	$709,187	$10.52	8	73,395	$1,012,224	$13.79
Arkansas, California, Nevada,[a] and Texas	4	5,170	62,900	12.17	6	11,073	134,130	12.11
	11	72,567	772,087	10.64	14	84,468	1,146,354	13.57

[a] No production from Alabama and Nevada in 1917.

The small number of producers makes it impossible to publish totals for some States without disclosing the output of individual operators; consequently the distribution of output is grouped as above. The Eastern States continue to produce by far the larger part of the fuller's earth marketed; their eight operators reported approximately seven-eighths of the quantity and value of the entire output in 1918. Named in the order of their rank in output the producing States were Florida, Texas, Georgia, California, Arkansas, Alabama, Massachusetts, and Nevada. Florida, which has been the leading State in the production and value of fuller's earth since the beginning of the industry, reported about four-fifths of the total quantity and value in 1918, and Texas rose from third to second place, displacing Georgia.

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IMPORTS.

The imports of fuller's earth entered for consumption in 1918 continued to decline, being 4,387 tons, or 26 per cent, less in quantity and $10,882, or 6 per cent, less in value than in 1917. The decrease in quantity was principally in the wrought or manufactured earth (3,846 tons). Both varieties also showed decrease in value. The average price per ton at the port of shipment, as taken from the records of the Bureau of Foreign and Domestic Commerce, for all imported earth increased $2.75; for unwrought earth, $3.54; and for wrought earth, $2.66. The imports in 1918 were the smallest since 1901, except those in 1904 and 1908, but the value of imports in 1918 was exceeded by that of only two years, 1917 and 1914. The imports in 1914 were the largest recorded and exceeded those of 1918 in quantity by 12,370 tons, or 98 per cent, and in value by $29,548, or 18 per cent. With the return of normal conditions the imports in 1919 may be expected to show an increase, though as some of the former larger consumers of imported earth now use domestic earth the increase may not be large. The rates of duty on imported fuller's earth under the act of October 3, 1913, are, on unwrought and unmanufactured earth 75 cents per long ton; on wrought and manufactured earth, $1.50 per long ton.

Fuller's earth imported and entered for consumption in the United States, 1909–1918.

Year.	Unwrought or unmanufactured.			Wrought or manufactured.			Total.		
	Quantity (short tons).	Value.	Average price per ton.	Quantity (short tons).	Value.	Average price per ton.	Quantity (short tons).	Value.	Average price per ton.
1909	1,802	$12,492	$6.93	10,950	$88,659	$8.10	12,752	$101,151	$7.93
1910	2,160	14,399	6.67	14,427	118,146	8.19	16,857	132,545	7.86
1911	1,881	10,877	5.78	16,343	132,717	8.12	18,224	143,594	7.88
1912	1,970	11,619	5.90	17,139	133,718	7.80	19,109	145,337	7.61
1913	1,916	12,344	6.44	16,712	133,657	8.00	18,628	146,001	7.84
1914	1,468	9,283	6.32	23,509	185,800	7.90	24,977	195,083	7.81
1915	850	5,176	6.09	18,591	147,317	7.92	19,441	152,493	7.84
1916	1,132	7,742	6.84	15,669	131,922	8.42	16,801	139,664	8.31
1917	1,441	11,718	8.13	15,553	164,699	10.58	16,994	176,417	10.38
1918	900	10,502	11.67	11,707	155,033	13.24	12,607	165,535	13.13

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MAGNESITE.

By CHARLES G. YALE and RALPH W. STONE.

GENERAL CONDITIONS.

The year 1918 was a trying one for the domestic producers of magnesite. To begin with, temporary restrictions on shipments of freight into the territory east of Chicago because of freight congestion in that district made it difficult to get permission or cars to ship magnesite to the eastern consumers; second, the makers of refractory products practically stopped buying crude magnesite in the fall of 1917 and insisted on having calcined or dead-burned material, because its use would save 50 per cent in weight and in freight charges. Producers that were not equipped with kilns therefore lost business. Furthermore, the prices offered to small producers by some buyers were so low that they had to discontinue operations. At some mines there was a shortage of labor.

By midsummer there was a lack of orders in some fields. Magnesite from Porterville, Calif., was in much less demand for making refractory products, and as building operations were curtailed the call for California magnesite for use in plaster and flooring also diminished. In the fall there was a shortage of labor in both California and Washington, and the restriction on freight shipments to eastern points continued to harass the producers. With the signing of the armistice in November, which was followed by continued activity, but uncertainty in the steel industry, the eastern consumers of magnesite practically stopped placing new orders, probably in the belief that cheaper European magnesite would soon be available.

The imports of calcined magnesite from Quebec, Canada, though small as compared with the output in the United States, may have tended somewhat to reduce the domestic production. In 1917 these imports were about 3,000 tons, but in 1918 they increased rapidly and by May were approximately 2,000 tons a month. The Canadian magnesite contains much lime, but it could be delivered in much less time—a few days instead of several weeks—and at a much lower freight rate than the magnesite from California and Washington.

The condition in California during much of the year was therefore disheartening and a number of small producers and some larger ones suffered considerable financial loss.

The magnesite deposits of the United States as now developed are capable of easily supplying all the domestic demand for many years and of producing a surplus for export. These deposits, however, are in California and Washington, 2,000 to 2,500 miles from the principal market, which is among the steel plants and sanitary flooring plants in the area east of Mississippi River and north of Ohio River.

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At the time this is written (June, 1919) the American Mineral Production Co., at Valley, Wash., has been idle for several months; the Northwest Magnesite Co. closed its mine and plant at Chewelah, Wash., in May, 1919; the Sonoma Magnesite Co. and the Refractory Magnesite Co. in Sonoma County, Calif., are idle; the Western Magnesite Development Co.'s mine on Red Mountain, Santa Clara County, Calif., is working at only a fraction of its capacity; and the only companies in California that are mining much magnesite are the White Rock mine, the Porterville Magnesite Co., and the Tulare Mining Co. If Austrian and Grecian magnesite is imported before the stocks of domestic material now on hand are exhausted, it seems likely that the domestic magnesite industry will continue dull.

As one of the largest Austrian deposits is American-owned and as European magnesite may soon be delivered at New York, Philadelphia, and Baltimore at a much lower price than California and Washington magnesite, which has to bear higher wages and very high freight rates, domestic material may not long hold the market in the eastern United States.

MARKETS AND PRICES.

The principal markets for magnesite are the northeastern section of the United States of America and western Europe. This localization is based on the great steel industry, which in turn is centered on the deposits of iron and coal. Magnesite is used as a refractory material in making steel.

The large and long developed deposits of magnesite in Austria-Hungary and Greece supplied the world until recent years, low ocean freight rates making it possible to ship even crude material as far as North America and Australia. A large part of the Austro-Hungarian annual production was used in Germany, England, Russia, France, Belgium, and Italy. Grecian magnesite also was used in large part in western Europe. Formerly the equivalent of 300,000 tons of European crude magnesite was shipped annually to the United States. During 1917 and 1918 almost no foreign magnesite reached America, and the demand made by the steel plants was supplied by California and Washington, whose production of magnesite increased from 11,000 tons in 1914 to 316,000 tons in 1917, and in small part by Canada.

Before the war the price of Austrian crude magnesite per short ton on the Atlantic seaboard was $9 to $10, and Grecian crude was generally valued at a little more than $10. The average price of calcined magnesite at Atlantic ports was about $16.25 a short ton. Dead-burned Austrian magnesite sold as low as $15.72 f. o. b. docks at Philadelphia and $15.60 f. o. b. New York. California crude magnesite was about $8 a ton at the mines, which, with freight to a Pacific port and ocean carriage to Atlantic ports, brought the price of California crude material delivered on the eastern seaboard up to the price of imported calcined material at the same ports. As 1 ton of crude makes only half a ton of calcined magnesite, California material cost twice as much as European material at New York and Philadelphia before the war.

The average value per ton of Washington and California magnesite in 1918 was $7.12 and $9.06, respectively, and as the freight rate to

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the Atlantic coast was raised to $15.60, plus 3 per cent war tax, or $16.07, the cost of crude domestic magnesite at Atlantic ports rose to $23 to $25 a ton. New York market quotations in June, 1919, are $30 to $35 a ton for crude magnesite and $50 to $60 for calcined magnesite. There is no European magnesite on the market, but the cost of domestic material is so high that if European magnesite should enter the market, even at double its former price, the magnesite industry of the United States would probably fall back to an annual production of a few thousand tons.

PRODUCTION.

The crude magnesite produced and sold or treated in the United States in 1918 amounted to 231,605 short tons, valued at $1,812,601, f. o. b. mines or plants. As compared with an output in 1917 of 316,838 tons, valued at $2,899,818, this was a decrease of about 27 per cent in quantity and 37 per cent in value. The reduction was not general, however, for while the California output fell from 211,663 tons in 1917 to 84,077 tons, a decrease of 60 per cent, the Washington output increased from 105,175 tons in 1917 to 147,528 tons, or 40 per cent.

According to the best data available, the average price per ton of crude magnesite f. o. b. mine in California fell from $10 in 1917 to about $9.06 in 1918, and in Washington from about $7.45 in 1917 to $7.12 in 1918.

Crude magnesite produced and sold or treated in the United States in 1917–18.

State and county.	1917		1918	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.
California:				
Alameda, Kern, Riverside	3,292			
Fresno	6,077			
Fresno, Kern, Riverside			3,865	$32,884
Mendocino, Placer, San Benito, Tuolumne	5,161			
San Benito, San Bernardino			5,440	48,755
Napa	40,209		28,462	281,120
Santa Clara	9,410		11,522	101,198
Sonoma	5,386		4,045	39,798
Stanislaus	8,255		4,166	33,328
Tulare	133,873		26,577	224,728
	211,663	$2,116,630	84,077	761,811
Washington:				
Stevens	105,175	783,188	147,528	1,050,790
	316,838	2,899,818	231,605	1,812,601

Crude magnesite produced in the United States, 1913–18.

	Quantity (short tons).	Value.		Quantity (short tons).	Value.
1913	9,632	$77,056	1916	154,974	$1,393,693
1914	11,293	124,223	1917	316,838	2,899,818
1915	30,499	274,491	1918	231,605	1,812,601

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The quantity of crude magnesite produced and sold or treated in a year is not the same as the quantity mined, for some is mined and not sold, and the stocks on hand vary from year to year. The foregoing table does not include the ore mined but not sold, and therefore these figures do not agree with those reported by the California State Mining Bureau, which represent quantity mined, regardless of whether it was sold. According to the best available information at least 2,300 tons were mined in California but not marketed or treated, and the stock of crude rock in Washington at the close of the year was 8,000 tons.

The Geological Survey has a record showing that about 71,800 tons of California magnesite was calcined before shipment in 1918 and that it made approximately 33,800 tons of calcined and dead-burned magnesite. The remainder of the material sold was calcined after shipment. Thousands of tons of Washington magnesite were shipped crude and a few thousand tons were calcined in the early part of 1918, but during the remainder of the year all the output was made into ferromagnesite at Chewelah, Stevens County, and Irvin, Spokane County. By the fall of 1918 each of the two producing companies in Washington was able to make a monthly output of 4,000 to 5,000 tons of ferromagnesite, or 10,000 tons of crude magnesite.

The large increase in the production of magnesite in the United States began in 1915, and the output from California alone in 1916 had risen from 10,000 tons a year, the normal output, to more than 150,000 tons. This increase before the United States entered the war was due wholly to high prices arising from the stoppage of imports. Government encouragement to the magnesite industry was not necessary, because the raw material is abundant and the prevailing prices insured the mining of a sufficient supply.

During 1918 the Geological Survey received reports of production as of April 1, July 1, and October 1. This quarterly canvass of the industry furnished the data needed by the Council of National Defense, the War Trade Board, the Shipping Board, and other Government bureaus in following closely the progress of this industry. These reports showed that the production of magnesite in the six months ending June 30, 1918, was about 98,500 short tons, of which California produced 53,000 tons and Washington 45,500 tons. The production in the first half of the year was about 43 per cent of the total. Only two companies were producing in Washington in 1918, and one of these stopped quarrying from February to May in order to equip for larger business, thus diminishing the output. Washington made nearly 70 per cent of her production for the year in the second six months, whereas California made 63 per cent of her output in the first six months.

IMPORTS.

The following statistics of imports were obtained from the Bureau of Foreign and Domestic Commerce, Department of Commerce. In this table the imports of 1913 and 1918 are compared to show the decrease in the imports from European countries and the increase in the imports from Canada since the last normal year.

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Magnesite calcined, not purified, imported into the United States, in 1913 and 1918.

Country.	1913		1918	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Austria-Hungary	158,519	$1,499,647	.....	.....
Denmark	58	1,351	.....	.....
Germany	4,069	60,789	.....	.....
Greece	1,177	13,635	.....	.....
Netherlands	3,603	87,534	.....	.....
England	14	546	2	$507
Scotland	.....	.....	867	94,689
Canada	494	5,798	20,003	789,169
	167,934	1,669,300	20,872	884,365

Magnesite imported for consumption in the United States in 1918.

	Quantity (pounds).	Value.
Magnesia:		
Calcined, medicinal	523	$312
Carbonate of, medicinal	.....	.....
Sulphate of (epsom salts)	2,045	196
Magnesite:		
Calcined, not purified	38,098,815	824,022
Crude	10,864,000	103,233

Magnesite imported for consumption in the United States, 1909–1918.

Year.	Crude.		Calcined, not purified.	
	Quantity (pounds).	Value.	Quantity (pounds).	Value.
1909	19,635,479	$46,005	208,947,602	$939,014
1910	52,002,557	162,069	297,652,901	1,380,731
1911	25,948,797	76,097	244,149,581	1,109,770
1912	35,810,752	104,326	250,503,372	1,265,339
1913	26,479,109	84,911	334,187,404	1,672,565
1914	26,708,381	54,677	243,633,205	1,323,194
1915	99,527,772	255,140	53,148,739	232,071
1916	150,689,445	634,447	18,539,704	204,183
1917	60,554,420	232,105	7,931,159	232,601
1918	10,864,000	103,233	38,098,815	824,022

The following table showing by months the rapid increase and decrease of imports from Canada in 1918 is especially interesting in considering the competition of Canadian with domestic magnesite. The imports from that country had already begun to decline before the armistice was signed.

Magnesite, calcined, not purified, imported into the United States in 1918, in short tons.

Month.	Canada.	Scotland.	England.
January	215	152	1
February	286	98	.....
March	633	53	.....
April	2,600	71	.....
May	2,076	82	.....
June	2,765	.....	.....
July	2,569	.....	.....
August	2,498	272	.....
September	3,317	.....	.....
October	1,129	63	1
November	1,254	24	.....
December	570	52	.....
	20,003	867	2

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CONDITION OF INDUSTRY.

CALIFORNIA.

GENERAL FEATURES.

A very marked, discouraging, and unexpected change took place in the conditions affecting the magnesite industry in California in 1918, when, after a period of rapidly increasing prosperity for some five years, the demand for the mineral suddenly ceased. Prices fell to a marked degree; many mines were closed indefinitely and others were compelled to reduce their output from one-third to one-half. Most of the smaller mines and those at a distance from main-line railroads, where hauling by trucks was necessary, had to be closed at once when the demand began to fall off in the earlier months of 1918, and by the middle of the year only the larger mines were operating and even these had materially reduced the rate of output.

Crude magnesite produced in California, 1913-1918.

Year.	Producing mines.	Quantity (short tons).	Value.
1913	1	9,632	$77,056
1914	6	11,293	124,223
1915	16	30,499	274,491
1916	45	154,259	1,388,331
1917	65	211,663	2,116,630
1918	30	84,077	761,811

This table shows that there were 35 fewer producing magnesite mines in 1918 than there were in 1917. The decrease in quantity of ore sold in 1918, as compared with 1917, was 127,586 tons, and the decrease in total value in 1918, as compared with 1917, was $1,354,819. The average price for crude ore f. o. b. railroad shipping point nearest to mine in 1918 was $9.06 a ton and the ayerage price for calcined ore was $36.

In the report on this subject in 1917 an enumeration of the calcining plants in the State is given, together with ownership and exact location. As no changes of note have occurred it is not necessary to repeat this information here.

Two properties in the State, one in Napa County and one in Sonoma County, have natural ferromagnesite ore, which has been found satisfactory to use in refractory products, such as furnace lining and bricks. Magnesite from other California mines has been used for the same products by adding a small quantity of iron. California magnesite, as a rule, is preferred over Washington magnesite for plastic uses because it burns whiter.

REVIEW BY COUNTIES.

Alameda County.—The Cedar Mountain mine, formerly productive, is reported to have plenty of ore in sight but the market price early in the year would not permit of a profit, and later there was no demand, so there was no output. There were several calcining plants in operation in Alameda County but the ore treated was derived from other counties of the State.

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Fresno County.—Three deposits in Fresno County were productive in 1918, as compared with nine in 1917. Sinclair Bros. & Ferguson calcined ore from both the Ferguson and the Ward deposits, near Piedra. The plant closed in July, there being no market for the product. The Piedra Magnesite Co., formerly known as the Tarpey mine, operated its rotary kiln only until May 1, and the mine was then closed. The Hughes Creek, Levensaler-Spier, Hazel, Siebert, Terrill, and a few smaller properties were all inactive during the year.

Kern County.—The International Magnesite Co. purchased in January from the Rex Plaster Co., of Los Angeles, the Bissell magnesite deposit in Kern County, but the mine made only a small output in 1918. Early in the year the railroad blockade prevented shipments and later the rise of freight rates caused the mine to close down; it has been virtually abandoned.

Napa County.—In Napa County in 1917 there were seven productive magnesite mines, but in 1918 there were only four. The most prominent producer and, in fact, the largest in the State, was the White Rock (Sweasy) mine, in Pope Valley, where the ore was calcined in upright kilns. This is one of the two mines in the State which produces a natural ferromagnesite that is utilized for refractory purposes. Other producers were the White Cape, at Chiles Valley, the White Horse and Giant, and the Soda Creek. The two latter mines closed down as only part of the output was sold. The Tulare Mining Co., in Chiles Valley, reported a small output in the first quarter of 1918. Two of the kilns of Sears & Cubbage were used by the owners of the White Rock mine, in 1918. The Minerals Development Co., at Rutherford, went out of business in 1918 and made no production.

Riverside County.—The Magnesco Refractory Products Co. worked the old Winchester property in Riverside County part of the year. The ore from this mine is hand picked on a belt conveyor before going to the rotary calciner.

San Benito County.—A small output was made by the San Benito Magnesite Co. near New Idria in San Benito County and also from the Sampson deposit in the early part of the year. Before summer all mining ceased and the kilns were idle.

Santa Clara County.—Several claims near Madrone, in Santa Clara County, owned by the Bay Cities Water Co., were operated productively by lessees but were finally closed in the latter part of 1918 through lack of demand for the product. The Western Magnesite Development Co. on Red Mountain made a large output in the early months of the year, but the demand fell off entirely after July 1. This property was operated under a receivership. The Chicago and some adjoining unnamed claims were worked by the John D. Hoff Asbestos Co. for about six months, when lack of demand caused cessation of operations. The Standard was worked by lessees and reverted to the owner, Mrs. S. L. Stock, in July. A small quantity of ore was produced by J. H. Plattner from the Wasp mine on Red Mountain but not sold. All other properties on the Santa Clara County side of Red Mountain were unproductive in 1918.

Sonoma County.—The Sonoma Magnesite Co., near Cazadero, operated the most productive mine in Sonoma County in 1918. The entire output was calcined in the rotary kilns at the mine. A small

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output was made by the Leighton mine near Cloverdale. The Harker magnesite mine at Guerneville utilized its product in the manufacture of light carbonate of magnesia and has established this manufacture on a commercial basis. The Refractory Magnesite Co., near Preston, ground finely all its calcined material which is a natural ferromagnesite and made it into magnesite brick. The brick is manufactured at Stockton, San Joaquin County, and meets with ready sale at satisfactory prices. No output was made by any of the following known magnesite mines of the county: Standard Group, Cazadero; Cloverdale and Melville Ranch, at Cloverdale; Guerneville Farm Co., on Gillam Creek; Lucky Elsie and Sotoyome, at Healdsburg; and Morey deposit, at Warfield.

Stanislaus County.—The Bald Eagle mine, at Ingomar, Stanislaus County, owned by the Gustine Magnesite Co., made some output, but the ore was sold in the crude state to be calcined elsewhere. The Middletown mine, at Ingomar, shipped its ore for calcination to the Sedan Calcined Magnesite Co., at Emeryville, Alameda County, which controls the property. The most productive mine in the county was that of the Red Mountain Magnesite Co., formerly known as the Butcher. Shipping ceased at the mine at the end of June. The Manzanita, Burr Bros.' mine, and a few smaller mines were not operated during the year.

Tulare County.—For many years Tulare has been the leading county in California in the production of magnesite, but in 1918 her output was exceeded by that of Napa County. This was due to the activities of one large property in Napa County and to the curtailment of shipments from two of the larger mines in Tulare County because a certain extensive manufacturing enterprise, formerly drawing its supplies of calcined material from Tulare County, obtained them in 1918 from the State of Washington, as being nearer the point of consumption. The most productive mines in the county were those of the Tulare Mining Co., and the Porterville Magnesite Co., both near Porterville and both equipped with calcining plants. The ore from the mine of the Hawley Paper & Pulp Co. and the Lindsay Magnesite Co. is mixed and sold with the product of the Tulare Mining Co., which operates both properties. The ore of the Dinuba Magnesite Co. is sold crude. The customers of this property, as of some other mines, ceased buying ore and began to obtain their supplies from the State of Washington. The Rocky Hill (Duryea) mine, at Exeter, sold its ore crude. The Schrei mine, at Lindsay, made only a nominal output, there being little demand. The Oakland Magnesite Co., of Porterville, sold only crude ore, and there was no market for that after May. Among the idle mines in Tulare County, owing to lack of demand for the product, were the Blue Crystal and Montgomery, at Lindsay; and the American Magnesite Co., Avery, Hathway, Howeth, and Magnesite Refractories Co., at Porterville.

WASHINGTON.

Only two companies operated in Washington in 1918. The smaller of these mined more than twice as much magnesite as the largest producing country in California. Bad roads that made delivery to the railroad difficult in 1917 were overcome by a railroad direct to the quarries of one company and a 5-mile aerial tram to the quarry of the other.

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The American Mineral Production Co., shipping magnesite from Valley, Wash., changed its method of mining from quarrying to driving tunnels and taking the rock out through large funnel-like pits discharging into a tunnel beneath. The rock was calcined in vertical shaft kilns until March, after which it was shipped to Irwin, Wash., and there dead-burned in rotary kilns of the Inland Portland Cement Co. The American Mineral Production Co. did not produce magnesite after the signing of the armistice, when orders ceased because of the unsettled condition of the steel industry and the well-stocked magnesite market. According to H. F. Wierum, general manager of the company, production in 1918 was retarded by incomplete development up to the time of quitting (Dec. 1), by car shortage in the early months of the year, by labor shortage and influenza, and by the fact that the company was learning the business of sorting and calcining magnesite. At the end of 1918 the business was practically at a standstill, although some old contracts held over and were being filled early in 1919.

The Northwest Magnesite Co., shipping from Chewelah, made calcined magnesite in January and February, 1918, then stopped producing during March, April, and May to remodel its plant, so that a large output of ferromagnesite could be made. The manufacture of ferromagnesite began June 1 and continued to the end of the year. During the summer unusually dry weather caused a shortage of hydroelectric power and retarded production for a time. An auxiliary power plant of two gas engines having a combined capacity of about 400 horse power was installed to remedy this condition. R. B. Rogers, superintendent, reports that "unavoidable lack of development and preparation to meet the demand" retarded production by the Northwest Magnesite Co. in 1918.

The Valley Magnesite Co. made no production in 1918. Three shaft kilns with steel jackets were built and an aerial tram was delivered to the mine, which is on Deer Creek about 13 miles from Valley and close to the Red Marble quarry of the American Mineral Production Co. The latter company built a railroad from Valley to its Allen and Moss mines, 5 miles out, and built the grade, trestles, and bridges to Deer Creek, 8 miles farther. The output from the Allen and Moss mines proved sufficient, and although ties were cut and placed along the right of way the ties and rails were not laid on the last 8 miles of grade. Until this is done the Valley Magnesite Co. can ship only by making a long haul over a bad wagon road at a cost of $4 or more a ton.

The Crosby Magnesite Co. holds magnesite claims about 13 miles west of Valley on Deer Creek, near the Double Eagle mine of the Valley Magnesite Co. Development on these claims consisted in blasting and clearing away a small portion of rock at the base of the deposit, preparatory to opening up the face of a quarry. No magnesite was shipped during 1918.

NEW MEXICO.

According to Mr. J. H. Cauthen, general manager of the Great Eagle mine, Lordsburg, N. Mex., there is a body of magnesite from 1,000 to 1,500 feet long and at least 30 feet wide in the vicinity of the mine. The sample submitted by him in August, 1918, is to all

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appearances identical with the general run of magnesite occurring in veins and lenses in serpentine at many places in California. Mr. Cauthen furnished the following analysis made by Regis Chauvenet & Bro., St. Louis, Mo.:

Analysis of magnesite from Lordsburg, N. Mex.

Silica	0.60
Oxides of iron	.38
Calcium carbonate	4.03
Magnesium carbonate	94.99
	100.00

This analysis is lower in silica and higher in lime than most analyses of California magnesite in the tables on pages 151–152.

USES.

Practically all the magnesite produced in Washington is made into synthetic (artificially combined) ferromagnesite and goes in the dead-burned form to steel plants and to manufacturers of refractory products east of the Mississippi. None, so far as known, is used for plastic purposes, probably because it is not pure white. For Sorel cement white material is preferred so that white plaster may be used or may be colored by the addition of mineral pigments to suit the consumer's taste.

During the last three years a very large part of the California magnesite has been used for refractory purposes, and it is worthy of note that the entire output of the White Rock mine in Napa County, the largest producer in the State in 1918, is used by Pacific coast steel plants in their basic open-hearth and electric furnaces. The Refractory Magnesite Co.'s mine at Preston likewise yielded a natural ferromagnesite which was made into refractory brick at Stockton and used by smelters in California and Utah. The natural ferromagnesite of these two mines has made California a reputation for magnesite suitable for refractory as well as for plastic purposes. Whether the amorphous magnesite of California and the crystalline magnesite of Washington are equally suitable for refractory uses, in spite of claims for each, is a question which has arisen, but, so far as the Survey knows, has not been answered with incontrovertible evidence. From the little evidence in hand it would seem that technically they may be of equal value and that choice between them is based on results of calcination, difference in cost delivered to consumer, and time required for receipt of shipments.

All California magnesite, however, is not of the same composition. The two deposits mentioned above contain enough iron to constitute the product a natural ferromagnesite. The other productive deposits, so far as has been learned, carry only a very small percentage of iron.

ANALYSES.

The Geological Survey has not systematically sampled the magnesite mines in California and Washington, but the following analyses made in the chemical laboratory of the Survey from samples collected by Government geologists show the character of some of the material in a number of different deposits. The following table contains analyses of samples collected by R. W. Stone in 1917:

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Analyses of crude and calcined magnesite from California and Washington.

[Chase Palmer, analyst.]

	1	2	3	4	5	6	7	8	9	10
SiO_2	1.94	2.43	2.26	4.35	12.65	13.88	2.57	14.72	8.73	9.57
FeO	1.49	2.40	2.11	1.71	.80	1.49	.89	1.35	.97	1.00
CaO	.67	1.57	1.52	2.11	.95	.27	.80	.64	.39	2.83
MgO	45.01	43.62	44.10	42.62	40.73	39.60	45.65	39.60	43.18	42.48
CO_2	50.65	50.11	50.18	49.05	44.64	44.62	50.33	43.73	46.31	44.70
	99.76	100.13	100.17	99.84	99.77	99.86	100.24	100.04	99.58	100.58

	11	12	13[a]	14	15	16[a]	17	18	19	20
SiO_2	1.82	0.50	0.50	2.70	1.67	0.51	12.05	2.40	0.65	6.37
FeO	.50	.20	c.43	.23	.31	c.57	2.83	1.44	.33	.35
CaO	1.85	1.92	4.90	.80	1.17	2.48	1.98	3.68	2.65	2.88
MgO	45.12	45.90	83.17	46.02	45.75	90.30	38.88	42.56	45.43	41.55
CO_2	50.73	51.68	11.34	50.32	50.95	5.22	44.84	49.94	51.42	49.18
	100.02	100.20	100.34	100.07	99.85	99.08	100.58	100.02	100.48	100.33

	21	22[a]	23	24[a]	25[b]	26[a]	27	28	29
SiO_2	1.10	5.21	1.85	5.56	5.33	1.20	4.27	4.83	5.60
FeO	.72	c1.70	.88	c1.74	1.01	c2.36	.78	.85	.88
CaO	1.17	2.18	1.74	2.31	.35	.92	1.07	7.39	6.88
MgO	45.64	89.08	45.20	74.39	43.52	90.59	45.02	38.41	40.90
CO_2	51.20	1.65	49.70	15.95	47.91	5.23	49.51	47.81	46.03
	99.83	99.82	99.37	99.95	98.12	100.30	100.65	99.29	100.29

[a] Calcined.
[b] This sample contains also 1.81 per cent of material insoluble in acid.
[c] Fe_2O_3.

1. White Rock mine, bunker, Pope Valley, Napa County, Calif.
2. White Rock mine, east vein, stock pile, Pope Valley, Napa County, Calif.
3. White Rock mine, upper tunnel, Pope Valley, Napa County, Calif.
4. Tulare Mining Co., Blanco mine, stock pile, Chiles Valley, Napa County, Calif.
5. Soda Creek mine, Detert & Elder, south tunnel, stock pile, Soda Valley, Napa County, Calif.
6. Soda Creek mine, north tunnel, stock pile.
7. Harker quarry, stock pile, Gilliam Creek, Sonoma County, Calif.
8. Sonoma Magnesite Co. lower mine, stock pile, Austin Creek, Sonoma County, Calif.
9. Sonoma Magnesite Co. upper mine, stock pile.
10. Cedar Mountain mine, Clark & McDonald, sacked for shipping, Alameda County, Calif.
11. Western Magnesite Development Co., White Queen mine, 250 feet inside tunnel, Red Mountain, Santa Clara County, Calif.
12. White Queen mine, stock pile.
13. White Queen mine, kilns.
14. Pacific mine, bunker, Red Mountain, Santa Clara County, Calif.
15. Red Mountain Magnesite Co., Butcher mine, bunker, Red Mountain, Stanislaus County, Calif.
16. Butcher mine, cooling bins.
17. McLaughlin mine, stock pile on loading platform, Bradford ranch, Evergreen, Santa Clara County Calif.
18. Jackson mine, stock pile, Cochrane ranch, Morgan Hill, Santa Clara County, Calif.
19. Warwick mine, lower cut, stock pile, Madrone, Santa Clara County, Calif.
20. Warwick mine, upper cut, stock pile.
21. Hoff-Price Co. mine, stock pile, Sampson Peak, San Benito County, Calif.
22. Hoff-Price Co. mine, cooling floor.
23. Northwest Magnesite Co., Finch quarry, five freight cars, Chewelah, Stevens County, Wash.
24. Northwest Magnesite Co., cooling floor at kilns.
25. American Mineral Production Co., bunker at Allen quarry, Valley, Stevens County, Wash.
26. American Mineral Production Co., cooling at kilns.
27. American Mineral Production Co., Red Marble quarry, stock pile.
28. U. S. Magnesite Co., upper 40 feet of quarry 18 miles west of Springdale, Stevens County, Wash.
29. U. S. Magnesite Co., 18 feet in middle of quarry.

The following table includes analyses found in U. S. Geological Survey Bulletin 355, The magnesite deposits of California, by Frank L. Hess, 1908, and Bulletin 540–S, Late development of magnesite deposits in California and Nevada, by Hoyt S. Gale, 1913. These publications are no longer available for free distribution.

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Analyses of crude magnesite from California and Nevada.

	30	31	32	33	34	35	36	37
SiO_2	0.41	1.60	0.51	0.23	3.51	10.21	7.67	3.66
Al_2O_3	.28	.25	1.98	.04	1.10	.31	.26	.75
Fe_2O_3	.12	1.09	.16	.20	.80	.74	.29	.44
CaO	.03	1.04	.59	.19	1.46	.59	.04	.20
MgO	47.16	45.20	45.84	46.88	43.65	41.06	43.42	44.90
CO_2	51.88	50.43	50.80	51.77	49.16	44.76	48.08	49.20
	99.88	99.61	99.88	99.11	99.68	97.67	99.76	99.15

	38	39	40	41	42	43	44	45
SiO_2	2.15	0.30	0.73	0.31	2.28	0.80	0.20	0.14
Al_2O_3	1.22	.16	.14	.11	.03	.42	.04	.48
Fe_2O_3	1.16	.38	.21	.08	.26	.20	.12	
CaO	5.28	1.34	.40	.24	1.32	1.02	.96	.59
MgO	41.01	45.86	46.61	47.22	45.17	45.94	46.48	47.07
CO_2	48.72	51.80	51.52	51.64	50.74	51.80	51.80	50.66
Undetermined	.....	.....	.39	.....	.....	.....	.....	1.06
	99.54	99.74	100.00	99.60	99.80	99.68	99.60	100.00

	46	47	48	49	50	51	52	53
SiO_2	0.81	9.64	6.03	4.75	4.73	6.17	11.12	11.82
Al_2O_3	.00	2.46	1.40	.76	.12	.80	.98	.94
Fe_2O_3	.52				.08			
CaO	1.04	4.25	1.56	Trace.	.43	Trace.	5.36	5.90
MgO	46.67	37.19	42.78	44.20	44.77	43.80	36.72	36.40
CO_2	50.60	40.70	45.78	47.32	49.70	45.02	[a] 44.15	[a] 43.45
Undetermined	.36	5.76	2.45	2.97	.....	4.14	.....	.....
	100.00	100.00	100.00	100.00	99.53	100.00	98.33	98.51

[a] Determined by loss on ignition and therefore includes moisture.

30. Hixon ranch, near Pieta, Mendocino County, Calif. A. J. Peters, analyst.
31. Creon deposit (now Refractory Magnesite Co.), Preston, Sonoma County, Calif. A. J. Peters, analyst.
32, 33. Eckert ranch, near Cloverdale, Sonoma County, Calif. A. J. Peters, analyst.
34. Gilliam Creek, near Cloverdale, Sonoma County, Calif. A. J. Peters, analyst.
35. Gilliam Creek, Sonoma County, Calif. W. C. Wheeler, analyst.
36. East Fork of Austin Creek (Sonoma Magnesite Co.), Sonoma County, Calif. A. J. Peters, analyst.
37. East Fork of Austin Creek (Sonoma Magnesite Co.), Sonoma County, Calif. W. C. Wheeler, analyst.
38. Bartlett and Stanley claim, Chiles Valley, Napa County, Calif. A. J. Peters, analyst.
39. Burnett ranch, Coyote, Santa Clara County, Calif. A. J. Peters, analyst.
40. Alameda claim, Red Mountain, Santa Clara County, Calif. A. J. Peters, analyst.
41. Deer Creek, Tulare County, Calif. P. H. Bates, analyst.
42. Four miles northeast of Porterville, Tulare County, Calif. A. J. Peters, analyst.
43. Success, 9 miles east of Porterville, Tulare County, Calif. A. J. Peters, analyst.
44. Kings River, near Piedra, Fresno County, Calif. A. J. Peters, analyst.
45. Sampson deposit, San Benito County, Calif. J. G. Fairchild, analyst.
46. Sampson deposit, San Benito County, Calif. W. B. Hicks, analyst.
47–49. Bissell, Kern County, Calif. J. G. Fairchild, analyst.
50. Winchester, Riverside County, Calif. A. J. Peters, analyst.
51. Winchester, Riverside County, Calif. J. G. Fairchild, analyst.
52, 53. Muddy River, Clark County, Nev. W. B. Hicks, analyst.

There is the possibility that some of the analyses given in these tables may not fairly represent the product of a mine because the rock from different parts of a mine may vary somewhat in composition. For instance, the analysis of a sample taken from the bunker of the White Rock mine, Pope Valley, Napa County, Calif. (No. 1) is claimed by Frank R. Sweasy, who operates the mine, to be too low in iron and too high in lime.

Of all the California magnesite here shown, that of the White Rock mine, Napa County, Calif., is highest in iron content and at the same time reasonably low in silica and lime. Material from two small properties (Nos. 17 and 18) in Santa Clara County carries as much iron, but one is high in silica and the other is high in lime. The

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Refractory Magnesite Co.'s ore (No. 31) also is unusually high in iron. Many analyses of Washington magnesite made by reputable chemists have shown 1 to 3 per cent of calcium oxide, 1 to 2 per cent of iron oxide, and silica commonly between 2 and 6 per cent. It should not be concluded from the analyses herewith that the magnesite from the Finch quarry (23) is commonly so low in silica or that from the Allen quarry (25) commonly so high as shown.

FOREIGN DEPOSITS.

CANADA.

Quebec.—The principal magnesite deposits in Canada are in the Grenville district, Argenteuil County, Quebec. The deposits so far discovered in the Grenville district are in four principal localities about 12 miles north of Grenville. In general it may be said that the magnesite in all its occurrences is found in association with the metamorphosed group of sediments—crystalline limestone, garnet gneiss, and quartzite.

The magnesite in the Grenville district is a glistening cream-white to milk-white or gray crystalline material occurring in extensive masses associated with bands or lenses of dark-green to light-yellow serpentine. Throughout the great mass of the deposits magnesite and dolomite are so similar in appearance that the presence of dolomite is difficult to detect.

The most conspicuous structural features of the magnesite deposits are their prevailing lenticular forms. The deposits have been intensely faulted, crumpled, and otherwise deformed.

Outcrops of the deposits are as much as 1,000 feet in length and 300 feet in width. It is estimated that there are in sight 686,900 tons of magnesite containing less than 12 per cent CaO, and 483,700 tons of magnesite-dolomite containing more than 12 per cent CaO. These deposits were quarried extensively in 1918.

British Columbia.—In the Atlin mining district both magnesite and hydromagnesite have been observed, but extensive masses of hydromagnesite near the town of Atlin are the most important. These deposits are superficial beds of fine powdery white hydromagnesite 6 to 8 feet thick and covering areas 18 acres in extent. Two groups of these deposits are estimated to contain 180,000 tons of hydromagnesite. Shipments were made in 1918. The presence of magnesite is recorded also at Illecillewaet in the Kootenay district, on Germansen Creek in the Omineca district, at 108 Mile House on the Caribou road in the Lillooet district, and near the northwest end of Liza Lake in Bridge River district. Magnesite occurs also in other localities in Canada.

MEXICO.

On the island of Santa Margarita, in Magdalena Bay, Lower California, there are extensive deposits of magnesite from which exports have been made to the United States. Magnesite of the California type crops out on the hillsides, and hundreds of thousands of tons are said to be in sight. Large quantities can be obtained without mining and need only to be broken up for shipment. This ore was calcined in 1917 in a plant at Chula Vista, San Diego County, Calif.

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VENEZUELA.

Deposits of magnesite of the California type occur on Margarita Island off the coast of Venezuela. Most of them are in the northern part of the island, and the most accessible are along the beach. The supply of magnesite is estimated at 3,200,000 tons in six groups of deposits. An average of many analyses shows that the magnesite contains less than 0.5 per cent each of lime, iron, alumina, and silica. It is reported that the Magnesite Products Corporation, of New York, acquired 7,000 acres in 1916 estimated to contain 300,000 tons of magnesite. In 1915, 500 tons of magnesite were shipped to the United States, but there have been various hindrances to making shipments from the island in more recent years.

AUSTRIA-HUNGARY.

The magnesite deposits of Austria-Hungary, which until recently furnished much of the world's supply, follow a northeast line that extends for several hundred miles across the two countries. The mineral occurs in lenses, some of which are very large, and 10 or more of them are commercially workable. All the lenses are isolated, and many of them are too small to be worked profitably. The Austrian deposits extend across the Province of Steiermark, with the west end near the city of Salzburg and the east end near the town of Gloggnitz. The Veitsch deposit has been worked longer than the others. It is a huge lens on an isolated hill surrounded by barren rocks. The distance from the top to the base of the magnesite on the hill face is 700 to 800 feet. The mineral is quarried in a series of benches about 50 feet apart vertically.

Another very large deposit in Austria is at Radentheim, on the north side of the Millstatter Alps. The magnesite is quarried by great cuts, lowered by gravity to rotary kilns, and shipped from Trieste.

The Hungarian deposits extend from Totpelsoc to Kassa and eastward, perhaps into Russia. The largest deposits in Hungary are between the towns of Jolsva and Nyustya. The largest operations are at Nyustya, Gomor County, where the beds worked range from 150 to 300 feet in width and the rock is quarried by benches 50 feet high.

The magnesite contains chemically combined iron and is crystalline, two properties which cause it to calcine readily to the dead-burned state and make very satisfactory grain magnesite and brick for refractory purposes.

GERMANY.

Small irregular veins of magnesite in serpentine were worked for many years at Baumgarten and Grochan, south of Frankenstein, Silesia, but it is not known whether they are productive at present.

SPAIN.

In the Province of Santander in northern Spain, about 60 kilometers by rail from the seaport of Santander, coarse crystalline magnesite occurring in Lower Cretaceous limestone and dolomite has been

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mined for a number of years. The productive area is near Reinesa, between Fresno and Mina. Production has ranged from 500 to 2,000 tons in a year.

GREECE.

Grecian magnesite is of the noncrystalline type and occurs associated with serpentine in veins, masses, and stockworks. The largest veins are 50 feet or more in width and several hundred feet long. The best deposits are on the island of Euboea. The Euboean deposits are all close to the seashore, and under normal conditions cheap water transportation to the principal magnesite markets of the world is available. In 1912 the output was equivalent to about 150,000 tons of crude magnesite, exclusive of the product of one of the three largest producers.

The magnesite from Greece is practically identical in physical and chemical character with that from California.

Skiathas Island contains magnesite, probably in serpentine; there is no record of production.

MACEDONIA.

Magnesite is found in large quantities in Macedonia near the coast not far from the Greek border. It is of the compact type and occurs as veins in serpentine. The principal field covering several square miles lies 5 to 10 miles south of Salonika.

ITALY.

Magnesite veins of workable thickness occur at Castiglioncello and at Monternfoli, near the seaport Livorno, and have been worked in recent years. There are veins up to 10 inches thick in the Turin district, and on the island of Elba there is a stockwork of small veins in serpentine which has yielded several thousand tons.

NORWAY.

Magnesite occurs in Norway at Snarum, in the Modums division of Buskerud bailiwick, 35 miles from Dammen, the nearest city and seaport. It occurs as small veins in serpentine, but, unlike other magnesite in serpentine, it is crystalline.

SWEDEN.

Deposits similar to those in Norway are found in Sweden near Narbotten in Kvickjock parish on the north side of Terra River, and in Paturkorso Valley between Sulitelima and the North Sea. Veins 1½ and 4½ meters thick have been found.

RUSSIA.

Magnesite has been mined in the Orenburg government, east of Ufa, but no information is at hand regarding the character, extent, or ownership of the deposits. One mine yielded 26,320 metric tons in 1906. Other deposits are reported about 300 verts farther south, far from railroad. Magnesite occurs also in the Kuban district, on the north slope of the Caucasus Mountains.

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TRANSVAAL.

Extensive deposits of magnesite occur between Kaapmuiden and Malelane (Barberton district?), 2 miles south of the Pretoria-Delagoa Bay Railway, 87 miles from Lourenco Marquez. The magnesite is found in a great number of veins, 4 feet in maximum thickness, and has been mined to a depth of 100 feet. Most of the veins are much less than 3 feet wide, but there seems to be a large area of serpentine carrying them. Irregular veins of magnesite as much as 3½ feet wide occur also near Jacktlust, 51 miles southeast of Pietersburg.

RHODESIA.

Magnesia is reported to occur in Mashonaland, notably at Umtali and, in steatite, at the great Zimbabwe ruins. Probably it is in the form of magnesite.

PORTUGUESE WEST AFRICA.

Great deposits of magnesia are reported in the volcanic district of North Bihe, 200 miles east of Benguela. The deposits are near or associated with boiling springs and may be hydromagnesite.

INDIA.

Madras.—The most important occurrence of magnesite in India seems to be in the Chalk Hills, 4 miles northwest of Salem, Madras Presidency, in the southern part of the India peninsula. The magnesite occurs in interlacing veins, some of which stand several feet above the surrounding talcose, serpentinized, and other magnesian rocks. The main magnesite deposits occur over an area of 10 square miles and they have yielded more than 2,000 tons in a single year.

Mysore.—Magnesite deposits occur at a number of points near Mavinhalli and Kadakola, in Mysore, in the south-central part of the India peninsula. They do not seem to be of commercial importance, though the magnesite has been used locally as a substitute for lime. Deposits of unknown extent are reported near Yelwai.

ASIA MINOR.

Magnesite is reported in beds 3 to 15 feet thick, near Eskechehio station in Saruchan province, Turkey in Asia, about 75 kilometers from Smyrna.

MANCHURIA.

Coarsely crystalline magnesite that occurs as a bed in dolomite and limestone is exposed for long distances along the railroad in Manchuria Mountains. It is mined at Daisetsukyo, north of Darien.

AUSTRALIA.

Queensland.—All the deposits of magnesite in Queensland are so small that they probably have no commercial value. The deposit at Kilkivan is thought to be the largest.

New South Wales.—In New South Wales rounded blocks of pure-white magnesite outcropping over an area of 100 acres 3½ miles

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northwest of Fifield constitute the largest deposit reported. Many thousand tons is available at small cost, and 16,000 tons has been marketed. Veins and stockworks in serpentine at Attunga have yielded 2,000 tons, and veins 2 to 10 feet wide at Piedmont, near Barraba, have yielded 500 tons.

South Australia.—Large deposits of magnesite are reported in South Australia. One in Flinders Range, 11 miles east of Port Pirie, was worked to provide refractory material for smelters. Other deposits are 5 miles from Tumby Bay and at Robertstown.

Western Australia.—In Western Australia short irregular veins 2 feet thick occur at Bulong, northeast Coolgardie; and in Victoria veins 1 to 6 feet thick are known at Heathcote and a vein 2 to 4 feet wide occurs near Redesdale.

TASMANIA.

Magnesite deposits are reported in Tasmania but they may be merely mineralogic and not commercial occurrences.

NEW CALEDONIA.

Extensive deposits of magnesite occur on the north end of the west coast of New Caledonia. A small quantity has been exported.

WORLD'S PRODUCTION.

World's production of magnesite (estimated) in 1913 and 1917, in metric tons.

Country.	1913	1917
Australia	220	8,500
Austria-Hungary	[a] 400,000	[b]
Canada	1,600	[c] 58,000
Greece	96,600	145,000
India	16,000	17,640
Italy	600	.....
Spain	900	1,500
Transvaal	600	780
Turkey	8,000	[b]
United States	8,740	287,400
Mexico, Norway, Russia	5,000	5,000
	538,260	523,820

[a] Exports. [b] No data available. [c] Production in 1918.

The totals in the table above are of no value except as showing that the world's production of magnesite exceeds 500,000 tons annually. Austria-Hungary exported 400,000 tons in 1913 and may have used an equal quantity. If so the world's output would have been nearer 1,000,000 tons. Presumably the production of these countries for domestic use did not decrease during the war and may have equaled that of the rest of the world. No data are available on which to base an estimate.

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PRODUCERS OF MAGNESITE IN 1918.

CALIFORNIA.

1. California Magnesia Co., Guerneville.
2. Dinuba Magnesite Co., E. H. Kemble, secretary, Merchants National Bank Building, San Francisco.
3. Edward Duryee, Hollingsworth Building, Los Angeles.
4. Geo. W. Elder, 799 Oak Street, San Francisco.
5. Hugo Fischl, Hollister.
6. Dr. Carl G. Gohlin, St. Helena.
7. Gustine Magnesite Co., Ingomar.
8. H. L. Haehl, Humboldt Bank Building, San Francisco.
9. John D. Hoff Asbestos Co., Monadnock Building, San Francisco.
10. Fred Leighton, Cloverdale.
11. Magnesco Refractory Products Co., Winchester.
12. Nichelini & McKenzie, Chiles.
13. Oakland Magnesite Co., Realty Syndicate Building, Oakland.
14. Piedra Magnesite Co., 1411 Merchants National Bank Building, San Francisco.
15. J. H. Plattner, Patterson.
16. Porterville Magnesite Co. of California, Porterville.
17. Red Mountain Magnesite Co., Russ Building, San Francisco.
18. Refractory Magnesite Co., Preston.
19. Dr. R. Schiffman, Pasadena.
20. E. F. Schrei, Lindsay.
21. Sedan Calcined Magnesite Co., 253 Russ Building, San Francisco.
22. Hugh Sherlock, Madrone.
23. Sinclair & Ferguson, Fresno.
24. Sonoma Magnesite Co., Humboldt Bank Building, San Francisco.
25. Standard Magnesite Co., Livermore.
26. J. W. Swan, San Bernardino.
27. Frank R. Sweasy, Humboldt Bank Building, San Francisco.
28. Tulare Magnesite Co., 310 Sansome Street, San Francisco.
29. Western Magnesite Development Co., 704 Clunie Building, San Francisco.

WASHINGTON.

1. American Mineral Production Co., 732 Marquette Building, Chicago, Ill.
2. Northwest Magnesite Co., Chewelah, Wash.

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SODIUM AND SODIUM COMPOUNDS.

By Roger C. Wells.[1]

INTRODUCTION.

The various compounds of sodium consumed in the United States, with the exception of common salt, are obtained chiefly by chemical processes, but small quantities of so-called natural soda and sodium sulphate are made each year from natural deposits of these salts. The natural salts are also usually subjected to some refining process before use, so that practically every sodium compound, except common rock salt, may be considered a manufactured product. It is obvious, however, that no report which does not include the total production of all the compounds can adequately represent the industry.

The continued cooperation of the principal producers of sodium compounds in supplying data on production as well as other information of general interest to the trade is hereby gratefully acknowledged.

DISTRIBUTION OF SODIUM IN NATURE.

The element sodium is very widely distributed in nature. It forms about 2.36 per cent of known terrestrial matter and is the most abundant of the alkali metals. Sodium appears to occur in nature only in combination with other elements, if its alleged occurrence as the free element in blue rock salt is neglected.

Sodium is an important constituent of the feldspars and several other insoluble minerals from which sodium salts are not extracted commercially, but which are nevertheless regarded as the ultimate source of the salts that are soluble in water.

Sodium chloride is obtained by simple evaporation from sea water, the water of the Great Salt Lake, and many natural brines. Sodium carbonate and trona are thus obtained from the water of Owens Lake. The brine of Searles Lake yields on complete evaporation sodium chloride, sodium sulphate, sodium carbonate, and sodium borate, but these salts can be separated only by elaborate treatment.

The soluble salts above mentioned, as well as sodium nitrate, are found at or near the surface in dry desert regions, but elsewhere they are carried in solution to the sea. The deposits of sodium nitrate in northern Chile and the deposit of sodium carbonate at Magadi, British East Africa, are conspicuous examples of accumulation due to favorable geologic and climatic conditions. Many beds of rock salt in various regions have probably originated similarly and have been preserved from solution by impervious covers. Large deposits of salt

[1] The statistics of production in this report were collected by Miss A. T. Coons, of the United States Geological Survey.

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have been found at considerable depths in Michigan, Kansas, Louisiana, Texas, and New York, in the Stassfurt region in Germany, at Salzburg in Austria, in the Province of Orenberg in southeastern Russia, at Northwich in Cheshire, England, in Alsace and Lorraine, and in many other regions. From the soluble natural or crude salts are derived all the refined salts described in the following pages.

TRADE NAMES FOR VARIOUS SODIUM COMPOUNDS.

The name soda was originally used to mean sodium oxide, Na_2O, the name being analogous to those of other basic oxides. However, it has long been used in trade for the carbonate and in household economy for the bicarbonate and the hydrated carbonate, known as sal soda, and is frequently applied indiscriminately to all compounds of sodium, as "nitrate of soda." The better usage is to call such substances "sodium" compounds—for instance "sodium nitrate"—to prevent ambiguity.

The following table gives the various trade names, the chemical formula of the important constituent, the usual percentage of the compound designated in the marketed product, and the ordinary chemical name:

Trade names and formulas of sodium compounds.

Trade name.	Formula.	Percentage.	Chemical name.
Soda ash	Na_2CO_3	98–100 Na_2CO_3	Sodium carbonate.
Sodium sesquicarbonate, trona.	$Na_2CO_3.NaHCO_3.2H_2O$	47 Na_2CO_3. 37 $NaHCO_3$	Hydrated sodium carbonate-sodium bicarbonate.
Sal soda, washing soda, crystal carbonate.	$Na_2CO_3.10H_2O$	37.1 Na_2CO_3	Hydrated sodium carbonate.
Bicarbonate of soda, baking soda, saleratus.	$NaHCO_3$	99.5–99.7 $NaHCO_3$	Sodium bicarbonate or acid sodium carbonate.
Caustic soda	NaOH	75–99 NaOH	Sodium hydroxide.
Soda lime	NaOH+CaO		Sodium hydroxide and calcium oxide.
Borax Tincal	$Na_2B_4O_7.10H_2O$	52.7 $Na_2B_4O_7$	Sodium tetraborate.
Sodium hyposulphite "Hypo."	$Na_2S_2O_3.5H_2O$	64 $Na_2S_2O_3$	Sodium thiosulphate.
Yellow prussiate of soda	$Na_4Fe(CN)_6.10H_2O$	62.7 $Na_4Fe(CN)_6$	Sodium ferrocyanide.
Red prussiate of soda	$Na_3Fe(CN)_6.H_2O$	94 $Na_3Fe(CN)_6$	Sodium ferricyanide.
Sodium nitroprusside	$Na_2Fe(CN)_5NO.2H_2O$	88 $Na_2Fe(CN)_5NO$	Sodium nitroprusside.
Salt cake	Na_2SO_4	98–100 Na_2SO_4	Sodium sulphate.
Niter cake	$NaHSO_4$	61–86 $NaHSO_4$	Sodium bisulphate or sodium acid sulphate.
Glauber's salt	$Na_2SO_4.10H_2O$	44.1 Na_2SO_4	Hydrated sodium sulphate.
Chile saltpeter Soda niter	$NaNO_3$	95–96 $NaNO_3$	Sodium nitrate.
Water glass	$Na_2O.4SiO_2$ (approx.)		Sodium silicate.
Sodium carbonate monohydrate.	$Na_2CO_3.H_2O$	85–86 Na_2CO_3	Sodium carbonate monohydrate.

SUMMARY OF PRODUCTION.

The rule of the United States Geological Survey that the production of any single mineral or compound shall not be disclosed unless there are at least three producers of it or special permission is obtained, has necessitated reporting the production of some compounds in the following table in groups. The table summarizes the reported production of sodium and sodium compounds in 1918 and gives for comparison such figures as are available for 1917.

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Sodium and sodium compounds produced in the United States in 1917 and 1918.

	1917		1918	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Sodium (metal)	(a)	(a)	264	$153,437
Sodium acetate	1,049	$225,828	2,622	460,783
Sodium benzoate			203	886,058
Sodium bicarbonate	119,177	4,029,499	118,535	3,293,153
Sodium bichromate and sodium chromate	22,446	9,045,133	28,334	9,868,118
Sodium bisulphite and sodium sulphite	13,707	300,668	16,362	478,482
Sodium bromide			574	438,730
Sodium carbonate:				
Soda ash	1,390,625	38,028,000	1,390,628	35,635,520
Monohydrate and sesquicarbonate	55,035	1,262,875	22,678	482,958
Sal soda	77,939	1,698,520	82,465	2,020,271
Sodium chlorate and sodium perborate	2,915	1,333,426	2,413	1,004,250
Sodium chloride: b				
Salt in brine	2,890,588	1,083,586	2,830,600	1,245,265
Rock salt	1,605,025	3,897,595	1,683,941	5,684,661
Evaporated salt	2,482,564	14,959,261	2,724,203	20,010,435
Sodium cyanide, sodium iodide, and sodium peroxide	9,694	6,133,000	9,086	5,427,240
Sodium ferrocyanide	4,173	2,577,667	4,525	2,690,110
Sodium fluoride, acid sodium fluoride, and sodium fluosilicate (silicofluoride)	1,424	397,305	1,228	281,264
Sodium hydroxide (caustic soda)	488,056	29,402,689	513,363	31,854,470
Sodium nitrite	861	480,145	1,701	609,779
Sodium phosphate (including all sodium phosphates)	13,305	711,283	15,620	1,427,947
Sodium silicate	254,011	3,317,547	317,161	5,870,973
Sodium sulphate:				
Salt cake	183,909	2,987,641	141,054	2,844,897
Glauber's salt	47,757	732,403	50,715	1,041,070
Niter cake	387,821	780,278	143,155	595,660
Sodium sulphide	49,494	1,905,473	43,490	2,293,304
Sodium tetraborate (borax)	28,309	3,885,711	26,673	3,909,565
Sodium thiosulphate (hyposulphite)	26,598	717,924	26,868	1,051,623
Miscellaneous sodium compounds	4,563	2,062,300	381	1,122,552
	10,161,045	131,875,757	10,198,842	142,682,575

a Included in miscellaneous compounds.
b Stone, R. W., Salt, bromine, and calcium chloride; U. S. Geol. Survey Mineral Resources, 1918, pt. 2, pp. 119-121, 1919.

The production given in this table is practically identical with sales for most of the salts. This is especially true of soda ash, as the soda ash used by manufacturers in making caustic soda in their own plants is not included in the figures above. On the other hand, however, the caustic soda made and consumed in their own plants by paper manufacturers and others is included, as well as small quantities of certain other salts listed below, such as sodium bichromate, salt cake, and niter cake, consumed by the makers. A large quantity of niter cake is neither sold nor consumed but represents a waste product.

Sodium compounds used by the makers in their own plants in 1918.

	Quantity (short tons).	Value.
Soda ash	664,119	$13,627,000
Sodium acetate	2,236	349,085
Sodium bichromate	3,227	812,310
Sodium fluosilicate	87	12,975
Sodium hydroxide	79,207	5,077,891
Sodium silicate	56,096	1,076,621
Sodium sulphate:		
Glauber's salt	7,001	138,820
Niter cake	39,906	259,672
Salt cake	9,903	207,080
Sodium sulphide	3,269	153,967

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Sodium salts derived from natural sources in 1917 and 1918.

	1917		1918	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Sodium chloride:				
Salt in brine	2,890,588	$1,063,586	2,830,600	$1,245,265
Rock salt	1,605,025	3,897,595	1,683,941	5,684,661
Evaporated salt	2,482,564	14,959,261	2,724,203	20,010,435
Sodium carbonate, sodium bicarbonate, and sodium sulphate	21,743	895,602	24,053	992,788
	6,999,920	20,836,044	7,262,797	27,933,149

IMPORTS.

Sodium nitrate is the principal sodium salt imported. The imports of most of the other salts are very small compared to the domestic production, according to the records of the Bureau of Foreign and Domestic Commerce, which furnishes the data on imports and exports.

Sodium salts imported for domestic consumption in 1917 and 1918.

	1917		1918	
	Quantity (pounds).	Value.	Quantity (pounds).	Value.
Sodium arsenate	23,296	$2,404	35	$88
Sodium benzoate	42,561	197,284	54,150	11,469
Sodium bicarbonate[a]	35,737	1,660	12,383	629
Sodium carbonate:				
Soda ash	2,063,571	70,080	1,445	29
Monohydrate and sesquicarbonate	45,650	1,179	44,800	1,281
Sal soda	100	5	25	2
Sodium chlorate	33,600	1,080	44,810	8,066
Sodium chloride (common salt)	129,844,300	280,135	80,580,700	281,468
Sodium chromate and sodium bichromate	22,025	4,075	5,102	1,184
Sodium cyanide	1,622,118	826,052	69,279	12,615
Sodium ferrocyanide (yellow prussiate of sodium)	22,048	13,454	271,063	98,505
Sodium hydroxide or caustic soda	146,236	17,773	2,002	193
Sodium nitrate	3,456,780,000	60,727,100	4,138,758,400	90,216,935
Sodium nitrite	8,767,415	349,111	2,857,631	289,182
Sodium phosphate	437	180	.....	.....
Sodium silicate	936,576	15,963	464,461	9,902
Sodium sulphate, crude, or salt cake and niter cake	984,000	8,583	138,880	947
Sodium sulphide	288,292	5,104	112,821	4,673
Sodium sulphite	1,268	30	30,450	1,287
Sodium tetraborate or refined borax	110	7	2	1
Sodium thiosulphate, or sodium hyposulphite	5,840	5,748	1,120	975
	3,601,665,180	62,527,007	4,223,449,559	90,939,431

[a] Or supercarbonate, or saleratus, and other salts containing 50 per cent or more of sodium bicarbonate.

EXPORTS.

The domestic exports of sodium salts in 1918 were only slightly less than those in 1917, which were the largest ever recorded.

Value of domestic sodium salts exported, 1914–1918.

1914 (July 1 to Dec. 31)	$1,320,963
1915	7,725,034
1916	17,571,439
1917	23,384,969
1918	22,291,735

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Domestic sodium salts exported in 1917 and 1918, by classes.

	1917		1918	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.
All soda	.....	[a] $9,322,233	.....	.....
Sodium carbonate:				
Soda ash	[b] 49,210	[b] 2,884,569	119,217	$7,805,550
Sal soda	[b] 3,718	[b] 97,772	6,358	213,865
Sodium chloride (common salt)	113,993	1,000,773	136,783	1,677,577
Sodium hydroxide (caustic soda)	[b] 44,997	[b] 5,832,598	48,689	5,602,813
Sodium silicate	[b] 7,275	[b] 216,828	14,125	404,796
All other salts of sodium	.....	[b] 4,030,196	.....	6,587,134
	.....	23,384,969	.....	22,291,735

[a] Six months, January-June. [b] Six months, July-December.

Foreign sodium salts reexported, 1915–1918.

Year.	Sodium chloride (common salt).		Sodium cyanide.		Sodium nitrate.		All other sodium salts.
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Value.
1915	52	$31,841	949	$347,079	25,472	$1,123,761	$40,358
1916	7,448	61,525	111	58,265	60,079	3,432,273	193,066
1917	1,900	21,830	138	115,067	78,152	5,367,281	25,632
1918	723	13,903	(a)	145	61,271	5,204,413	73,402

[a] 125 pounds.

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Sodium compounds exported in 1918, by countries.[a]

Country.	Sodium chloride (common salt).		Soda ash.		Sal soda.		Caustic soda.		Sodium silicate.		All other.	Total.
	Quantity (pounds).	Value.	Quantity (pounds).	Value.	Quantity (pounds).	Value.	Quantity (pounds).	Value.	Quantity (pounds).	Value.	Value.	Value.
Europe.												
Denmark			389,230	$15,881			800,000	$40,000			$4,450	$60,331
France	10,000	$150	299,780	13,043			3,922,065	132,390			138,316	283,909
Greece											750	750
Iceland and Faroe Islands	51,284	2,031	3,500	128	33,055	$896					1,792	4,847
Italy	4,400	67	187,674	5,678			4,959,037	376,498			33,430	415,673
Norway	2,160	84	7,287,082	280,265			112,000	5,238	342,110	$9,022	15,369	309,978
Portugal											12,933	12,933
Russia in Europe	27,714	241										241
Spain							1,334	92			95,530	95,622
Sweden			2,613,835	81,863					570,400	15,000	10,770	107,633
Switzerland	26,000	390									33,272	33,662
United Kingdom:												
England	56,694	406							15,919	826	620,028	621,260
Scotland											42,524	42,524
North America:												
Bermuda	295,650	2,909	560	29	21,056	491	637	56	140	2	340	3,827
British Honduras	611,722	4,598	60	3	19,878	477			60	1	343	5,422
Canada	160,360,923	617,907	73,226,543	1,911,488	9,237,685	136,194	12,423,267	579,109	23,309,140	253,132	2,309,446	5,807,276
Central American States:												
Costa Rica	240,819	4,200	47,786	2,060	8,725	187	117,274	7,915	22,635	640	5,434	20,436
Guatemala	173,521	1,876	1,680	77	9,055	137	5,311	367			2,327	4,784
Honduras	2,159,241	16,892	103,400	4,813	9,736	302	91,166	6,876	24,747	516	37,262	66,661
Nicaragua	557,894	6,883	191,664	7,432	11,884	343	396,992	25,577	20,875	551	13,857	54,643
Panama	5,881,821	49,707	107,058	3,708	328,605	7,384	234,823	12,750	148,786	3,772	5,915	83,236
Salvador	5,735	194	142,300	5,483	1,000	20	240,978	13,142			4,579	23,418
Mexico	6,958,031	78,554	4,658,011	140,918	167,553	5,267	5,380,218	298,349	1,007,411	36,587	924,297	1,483,972
Miquelon, Langley, etc	1,346	23			7,000	111						134
Newfoundland and Labrador	5,827,019	48,115	2,240	90	6,450	176	50	5	45,399	1,317	994	50,697
West Indies:												
British—												
Barbados	1,952	48	100	6	17,160	367	48,685	3,316			2,265	6,002
Jamaica	43,749	295	3,036	138	177,823	4,212	4,100	225	4,125	92	10,509	15,471
Trinidad and Tobago	3,105	88	8,300	171	96,769	2,019	9,284	512	28	41	2,692	5,528
Other British	15,262	428	1,300	20	31,583	748	628	247			3,296	4,739
Cuba	58,498,163	530,669	10,428,222	178,487	1,358,567	27,028	8,856,688	414,088	1,209,050	29,058	155,926	1,335,256
Virgin Islands	3,957	100	16,460	586	16,851	546	11,919	748			1,248	3,228
Dutch	487	10	1,000	35	26,675	824	1,090	80			4,079	5,028
French	20,158	572			2,125	52	10,273	630			1,845	3,099
Haiti	12,989	430	68,400	805	2,975	77	100	8			1,378	2,698
Dominican Republic	572,821	5,320	22,913	711	4,239	109	291,246	13,999	65,000	1,476	7,041	28,656

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South America:												
Argentina	26,140	1,015	3,650,771	133,206	353,000	4,970	5,806,845	260,606	19,687	750	127,288	536,353
Bolivia	320	9	7,848	266	10,500	195	169,190				5,034	11,667
Brazil	7,046		14,315,702	506,304	44,150	592	13,870,301	899,144	58,540	8,205	263,373	1,750,805
Chile	27,044	127	5,706,625	179,455	228,239	5,752	2,123,405	83,788	195,902	5,430	131,320	466,203
Colombia	189,362	452	741,998	29,330	38,022	1,214	1,000,679	79,956	19,366	875	21,139	135,212
Ecuador		2,698	183,292	6,984			170	25	4,649	197	4,606	11,762
Guiana:												
British	18,453	334	1,800	68	115,281	2,343	94,050	6,545			2,853	12,138
Dutch	6,010	132	672	22	2,237	51	8,500	175			360	740
French	17,000	198									151	349
Paraguay	14,000	175	66,980	1,117			60,010	1,558			14	2,864
Peru			746,802	32,004	29,366	869	1,524,049	69,996	56,346	1,558	42,138	146,564
Uruguay			400,940	12,337			1,509,622	78,649			22,868	113,854
Venezuela			1,608,763	56,958	8,345	180	737,143	39,318	316,479	13,966	19,090	129,512
Asia:												
China	28,175	1,710	1,409,182	69,316	3,917	82	1,850,578	129,384	114,608	2,446	12,258	215,196
Chinese leased territory (Japanese)	74	6	332,870	13,987			149,350	8,512	59,486	1,356	250	24,111
Chosen	5,819	225			160	6	100,320	8,500			2,251	10,982
East Indies:												
British:												
British India	42,269	2,975	25,384	794	9,000	228	698,125	47,630			15,955	67,582
Straits Settlements	7,345	439			125	2	20,160	1,411			89	1,941
Other British	11,882	755					43,015	5,000			2,770	8,525
Dutch	498,712	17,783	996,773	45,753	50,690	963	998,246	73,692	4,380	90	70,633	208,914
French	6,979	283									68	351
Hongkong	7,077	467	215,100	6,753	26,808	1,198	328,044	28,680	171,271	4,116	5,473	46,687
Japan	2,418,230	13,369	94,884,796	3,417,074	183,000	6,525	19,857,155	1,381,907	108,133	7,780	755,404	5,582,059
Russia in Asia	70	2	132,000	6,082			4	4				6,088
Siam	7,586	233					50	8			776	1,017
Oceania:												
British:												
Australia	3,992,560	50,988	11,335,610	476,287			2,583,362	111,522	164,776	5,407	396,234	1,040,438
New Zealand	22,981,065	192,988	491,600	22,229			48,746	4,390	70,200	2,808	95,742	318,157
Other British	34,748	494	5,250	150	610	22	300	75			20	761
French	537,074	7,109	60,000	2,310	24,542	562	915	70	14,260	356	465	10,872
German	53,914	869									20	889
Philippine Islands	222,679	7,760	1,086,819	38,946	4,800	106	5,801,561	330,678	12,280	420	47,771	425,681
Africa:												
Belgian Kongo	7,876	143			286	8					443	594
British Africa:												
West	17,522	567					44,900	3,280			3	3,850
South	124	2	231,186	6,958	726	30	4,782	831	43,872	1,934	33,345	43,100
East	1,200	40									75	115
Canary Islands											12	12
Liberia	520	19									23	42
Morocco											11	11
Portuguese	1,004	21					192	8			2,566	2,595
French Africa	100	3										3
Total	273,565,496	1,677,577	88,434,992	7,805,550	12,716,453	213,865	97,378,334	5,602,813	28,250,360	404,796	6,587,134	22,291,735

a Compiled from records of Bureau of Foreign and Domestic Commerce.

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SODIUM COMPOUNDS IN RELATION TO THE WAR.

The war not only stimulated the chemical industry in the United States to produce sodium compounds that were formerly imported and to supply them to foreign countries, but, on account of the high cost of potash, brought about the replacement, either wholly or in part, of potassium compounds by sodium compounds in the manufacture of glass, soap, and matches, in photography, in medicine, in tanning, and in the manufacture of cyanide for extracting the precious metals from their ores. The need of chlorine for war purposes led to an increased production of caustic soda, which was itself in demand for making phenol used in making the picrates.

From August 1 to November, 1918, the exportation of caustic soda was under Government control through license. About the time the armistice was signed the prices of nearly all sodium compounds, which were then greatly advanced over pre-war prices, began to fall, and the decline continued well into 1919, leaving the producers in a very uncertain position with regard to possible tariff changes, foreign competition, and domestic demand.

Operation of the Government plant at Edgewood, Md., for making caustic soda and chlorine was discontinued in November, 1918. Most of the caustic soda made in this plant was used in the form of a dilute solution for absorbing residual obnoxious gases incidental to the production of the "war gases."

Although the present prices of many sodium compounds do not compare favorably with those of corresponding potassium compounds before the war, it is practically certain that pre-war prices for potassium compounds will not be again reached for a long time, so that the greater part of the substitutions that have occurred will be permanent. It may be noted that if the costs of production of sodium salts are equal to those of the corresponding salts of potassium per "molecule" the sodium salts have a slight advantage in lightness and hence in freight rates, as the atomic weights are 23 and 39, respectively.

The demonstrated inventiveness of the chemists and producers of the United States indicates that foreign competitors will not easily regain their former position in this country. Moreover, with one or two exceptions, raw materials are abundant in the United States, so that foreign competition will always have the handicap of the long ocean haul, although this may be cheaper than a long land haul. Obviously, however, a certain amount of international exchange is desirable, and it may be noted that although both imports and exports have increased in recent years the increase in imports has been due largely to sodium nitrate, whereas that in exports has been due to a considerable variety of manufactured compounds.

The principal producers of alkali in the United States have organized an export association under the laws of the State of Delaware, with offices at 171 Madison Avenue, New York City. The object of the association is to work for uniform and favorable conditions in the export business, with special regard to foreign banking facilities and to ocean freight rates.

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SODIUM (METAL).

The production of metallic sodium in the United States in 1918 amounted to 264 short tons, valued at $153,437. These figures can not be compared with similar figures for 1917, as reports were received from only two producers in that year, but the production in 1917 is included under the heading of miscellaneous compounds.

Metallic sodium is used in the manufacture of sodium cyanide, sodamide, sodium peroxide, and indigo, as well as in the laboratory. It has been proposed to use it in desulphurizing petroleum, and some was formerly used in reducing such metals as magnesium and titanium from their chlorides.

Metallic sodium is made commercially by electrolyzing fused sodium hydroxide at about 330° C. The Darling process, formerly used at Philadelphia, employed sodium nitrate. Attempts have been made to use the chloride, but its high melting point (800° C.) introduces many difficulties.

Sodium may also be made by heating sodium carbonate or other sodium salts with charcoal, and when so made it is separated from the reaction mixture by distillation. Patents have been granted for producing metallic alloys by electrolysis, the alloys being run off and the sodium distilled.

In United States patent 1265360, issued to W. L. Morrison, May 7, 1918, it is proposed to make a basic sodium silicate and hydrogen from caustic soda and silicon or ferrosilicon, and then to make metallic sodium from the sodium silicate by means of more silicon and lime.

The production of alkaline metals from fused halides by electrolysis forms the subject of United States patent 1258529, issued to J. Brode, March 5, 1918.

Metallic sodium was produced in 1918 by—

Dow Chemical Co., Midland, Mich.
Niagara Electro Chemical Co., 100 William Street, New York, N. Y.
Semet-Solvay Co., Syracuse, N. Y.

SODIUM ACETATE.

Sodium acetate, crystals of which have the formula $NaC_2H_3O_2.3H_2O$, is manufactured in the process of purifying acetic acid obtained in the distillation of wood. It is used in making acetic acid and dry colors, in dyeing, in photography, in purifying glucose, and in medicine. Sales of this material in the United States in 1918 amounted to 2,622 short tons, valued at $460,783, compared with 1,049 short tons, valued at $225,828, in 1917.

Sodium acetate was manufactured in 1918 by

Anderson Chemical Co., Wallington, N. J.
Dow Chemical Co., Midland, Mich.
Grasselli Chemical Co., Cleveland, Ohio.
Heyden Chemical Works, 135 William Street, New York, N. Y.
Maas & Waldstein Co., 92 William Street, New York, N. Y.
McKesson & Robbins (Inc.), 91 Fulton Street, New York, N. Y.
Mallinckrodt Chemical Works, St. Louis, Mo.
Powers-Weightman-Rosengarten Co., Philadelphia, Pa.
E. R. Squibb & Sons, 78 Beekman Street, New York, N. Y.

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SODIUM BENZOATE.

Sodium benzoate ($NaC_7H_5O_2$) is manufactured from benzoic acid, which is obtained from light tar oils by several processes, from gum benzoin, or is made synthetically. Its principal use is as a preservative. A small quantity is also used in medicine, in making certain aniline blues, and in printing textiles.

The production reported to the United States Geological Survey for 1918 amounted to 203 short tons, valued at $886,058.

Sodium benzoate was manufactured in 1918 by

Chromos Chemical Co., Aeolian Hall, New York, N. Y.
Doherr, Grimm & Co., 87 Gold Street, New York, N. Y.
Heyden Chemical Works, 135 William Street, New York, N. Y.
Hord Color Products Co., 1636 Columbus Avenue, Sandusky, Ohio.
Mallinckrodt Chemical Works, St. Louis, Mo.
Niagara Alkali Co., Niagara Falls, N. Y.
Seydel Manufacturing Co., 86 Forrest Street, Jersey City, N. J.
E. R. Squibb & Sons, 78 Beekman Street, New York, N. Y.
C. H. Stuart & Co., Newark, N. J.

SODIUM BICARBONATE.

Sodium bicarbonate, or mono sodium carbonate, familiarly known as baking soda ($NaHCO_3$), if theoretically pure has the composition Na_2O, 36.90 per cent; H_2O, 10.72 per cent; CO_2, 52.38 per cent. It is commercially known in grades specifying the percentage purity of the salt itself, the greater part reported being 99.5 to 99.7 per cent. Its principal use is in baking.

The domestic production reported in 1918 was 118,535 short tons, valued at $3,293,153, compared with 119,177 short tons, valued at $4,029,499, in 1917. These figures do not include material that is mixed with soda ash and used in cleaning compounds.

In the following table the production of sodium bicarbonate for the years 1899, 1904, 1909, and 1914 is taken from the report of the Bureau of the Census,[1] and for the other years the figures are supplied by the Geological Survey.

Sodium bicarbonate produced in the United States in certain years.

	Quantity (short tons).	Value.		Quantity (short tons).	Value.
1899	68,856	$1,332,765	1916	115,117	$2,303,540
1904	68,869	1,135,610	1917	119,177	4,029,499
1909	82,800	1,515,045	1918	118,535	3,293,153
1914	90,169	1,439,014			

Sodium bicarbonate is the first product obtained in the manufacture of sodium carbonate by the ammonia process, as described on page 173. The bicarbonate made in this way, however, contains a small quantity of ammonia, which renders it unfit for most purposes for which sodium bicarbonate is used, and it must be treated further to obtain a pure salt—for example, it may be either partly calcined and recarbonated or entirely recrystallized or reprecipitated under suitable conditions.[2]

[1] Chemicals and allied industries: Census of manufactures, p. 18, U. S. Dept. Commerce Bur. Census, 1918.
[2] Martin, Geoffrey, The salt and alkali industry, p. 79, London, 1916.

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The following firms manufactured sodium bicarbonate in 1918:

Mathieson Alkali Works (Inc.), Saltville, Va.
Michigan Alkali Co., Wyandotte, Mich.
Natural Soda Products Co., Keeler, Calif.
Solvay Process Co., Syracuse, N. Y.

SODIUM BICHROMATE AND SODIUM CHROMATE.

Sodium bichromate ($Na_2Cr_2O_7.2H_2O$) has come into extensive use in the last few years in tanning leather on account of the scarcity of the potassium bichromate previously used, and is said to be just as satisfactory as a tanning agent. It is also used in making paints, in refining the precious metals obtained from the cyanide solution by means of zinc, as a mordant, principally in wool dyeing, and as a laboratory reagent.

In making sodium bichromate sodium chromate is first made by heating the mineral chromite with soda ash and lime. The object of the lime is to prevent fusion and keep the mass porous to facilitate oxidation. The roasted mass is extracted with water containing some sodium carbonate to convert any calcium chromate into sodium chromate, and after separation of the solids the solution is allowed to crystallize or is treated with sulphuric acid to form sodium bichromate, which is freed from the sodium sulphate by evaporation and crystallization.

Sodium chromate ($Na_2CrO_4.10H_2O$) is not used so extensively as the bichromate, on account of its hygroscopic character and because of its lower content of chromic anhydride.

The production of these two salts in the United States in 1918 amounted to 28,334 short tons, valued at $9,868,118, as compared with 22,446 short tons, valued at $9,045,133, in 1917.

The imports of sodium bichromate and sodium chromate in 1918 were 5,102 pounds, valued at $1,184, as compared with 22,025 pounds, valued at $4,075, in 1917.

Sodium bichromate is manufactured by the following firms:

Martin Dennis Co., Newark, N. J.
E. I. du Pont de Nemours & Co., Wilmington, Del.
Grasselli Chemical Co., Cleveland, Ohio.
Mutual Chemical Co. of America, 55 John Street, New York, N. Y.
National Electrolytic Co., Niagara Falls, N. Y.
Natural Products Refining Co., Jersey City, N. J.
Sawyer Tanning Co., Napa, Calif.
Sherwin Williams Co., Cleveland, Ohio.

Sodium chromate is also made by the Mutual Chemical Co. of America and the Mallinckrodt Chemical Co.

SODIUM BISULPHITE AND SODIUM SULPHITE.

Sodium sulphite (Na_2SO_3), sodium bisulphite ($NaHSO_3$), and sodium polysulphite are all made from sodium carbonate and sulphur dioxide and are used as a source of sulphur dioxide in making wood pulp, sterilizing brewer's casks, as reducing agents in photography, dyeing, and bleaching, as a depilatory in cleaning hides, and for removing traces of chlorine where a chlorine bleach has been used. Sodium sulphite may also be made by heating a mixture of sodium sulphate and iron in an atmosphere of sulphur dioxide.

The total production of these salts in the United States in 1918 amounted to 16,362 short tons, valued at $478,482, compared with 13,707 short tons, valued at $300,668 in 1917.

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The following list gives the domestic manufacturers of sodium sulphite, sodium bisulphite, and sodium polysulphite, in 1918:

Sodium sulphite:
Charles Cooper & Co., 194 Worth Street, New York, N. Y.
Grasselli Chemical Co., Cleveland, Ohio.
Mechling Bros. Manufacturing Co., Camden, N. J.
Semet-Solvay Co., Syracuse, N. Y.

Sodium bisulphite:
Atlantic Carbonic Co., 268 Third Street, Chelsea, Mass.
Charles Cooper & Co., 194 Worth Street, New York, N. Y.
Grasselli Chemical Co., Cleveland, Ohio.
A. Lee Co., Lawrence, Mass.
Charles Lennig & Co., 112 South Front Street, Philadelphia, Pa.
Mallinckrodt Chemical Works, St. Louis, Mo.
Mechling Bros. Manufacturing Co., Camden, N. J.
Merrimac Chemical Co., 148 State Street, Boston, Mass.
D. D. Williamson & Co., 86 Fulton Street, New York, N. Y.

Sodium polysulphite:
Charles Cooper & Co., 194 Worth Street, New York, N. Y.

SODIUM CARBONATE.

SODA ASH.

PRODUCTION.

Soda ash is the commercial term used for normal sodium carbonate without water of crystallization (Na_2CO_3; theoretically Na_2O 58.49 per cent, CO_2 41.51 per cent). It is supplied commercially in various grades, described, according to reports of the Department of Commerce,[1] as 58 per cent, dense 58 per cent, 48 per cent, special 48 per cent, and 36 per cent. The percentages refer to the content of sodium (expressed as Na_2O). The figures reported by the producers in 1918 were all for the 58 per cent grade.

The soda ash produced and marketed as such in the United States in the calendar year 1918 amounted to 1,390,628 short tons, valued at $35,635,520. This compares with 1,390,625 short tons, valued at $38,028,000 in 1917, and with 1,194,183 short tons, valued at $16,464,774 in 1916. These figures do not include sodium carbonate reported in the form of monohydrate and sesquicarbonate nor the soda ash consumed by the manufacturers in their own plants in making caustic soda and other sodium compounds. The quantity of soda ash used for the latter purpose in 1918 was about 664,000 short tons, against 482,000 short tons in 1917. The following table gives such figures as are available for the annual production of soda ash:

Soda ash produced in the United States in certain years.[a]

	Quantity (short tons).	Value.		Quantity (short tons).	Value.
1899	390,653	$4,859,656	1916	1,194,183	$16,464,774
1904	518,954	8,204,545	1917	1,390,625	38,028,000
1909	646,057	10,362,656	1918	1,390,628	35,635,520
1914	935,305	10,937,945			

[a] The figures for 1899, 1904, 1909, and 1914 are from Chemicals and allied industries: Census of manufactures, p. 18, U. S. Dept. Commerce, Bur. Census, 1918.

[1] Chemicals and allied industries: Census of manufactures, p. 23, U. S. Dept. Commerce Bur. Census, 1918.

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This table shows a fairly normal increase until the beginning of the war. Since that time the increase has been rapid. It was estimated by Weldon [1] in 1883 that the entire soda trade of the world (sodium carbonate and sodium hydroxide in terms of sodium carbonate) amounted annually to only about 709,000 tons, a figure that shows, when compared with the present production in the United States alone, how rapidly chemical industry has advanced.

The manufacture of soda ash in the United States is confined almost entirely to New York, Ohio, Virginia, Michigan, California, and Kansas.

The following is a list of the producers of soda ash in 1918:

Columbia Chemical Co., Pittsburgh, Pa.
Diamond Alkali Co., Pitsburgh, Pa.
Mathieson Alkali Works (Inc.), Saltville, Va.
Michigan Alkali Co., Wyandotte, Mich.
Solvay Process Co., Syracuse, N. Y.
West Virginia Pulp & Paper Co., New York, N. Y.
California Alkali Co., San Francisco, Calif.
Inyo Development Co., Keeler, Calif.
Natural Soda Products Co., Keeler, Calif.

Of these nine companies the first five manufacture their material from salt brine, the last three have deposits of the natural salt, and one company incinerates the ash from spent pulp liquor.

IMPORTS AND EXPORTS.

The imports of soda ash for consumption in the United States in 1918 were less than 1 ton, according to the records of the Bureau of Foreign and Domestic Commerce, Department of Commerce. In 1917 they amounted to 1,032 short tons, valued at $70,080.

The exports in 1918 amounted to 119,217 short tons, valued at $7,805,550. For the last six months of 1917, the only period for which figures are available for 1917, the exports amounted to 49,210 short tons, valued at $2,884,569. The principal countries receiving this material in 1918, named in decreasing order of quantity exported to each, were Japan, Canada, Brazil, Australia, and Cuba. Japan received 47,442 short tons, valued at $3,417,074, and Canada 36,613 short tons, valued at $1,911,488.

PRICES.

The price of soda ash in the United States was hardly affected by the European war until late in 1915 and early in 1916. Quotations then rose to several times the previous figures, but during the summer and fall of 1916 the price fell somewhat, and remained fairly steady until the summer of 1917. In September, 1917, the Government was bidding insistently for caustic soda and the price of soda ash advanced to its highest point—light soda ash in bags was quoted at $4.20 a hundred pounds in the New York market. The price soon fell to about $3, however, and remained there for nearly the whole of the first quarter of 1918. It then fell to nearly $2, subsequently rose again to $2.60, and when the armistice was signed began a

[1] Sodium: Encyclopedia Britannica, 9th ed.

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decline that continued well into 1919, stopping at about $1.50. The average price in 1918 was therefore considerably lower than that in 1917.

It should be remembered that spot quotations usually fluctuate more widely than prices made on long-term contracts by large manufacturers, and also that prices regularly quoted in the New York market are much higher than those representing the value of the marketed product in large lots f. o. b. at point of shipment.

USES.

Sodium carbonate in the form of soda ash is the foundation of the alkali industry, for it is used in the manufacture of glass, soap, and dyes, as well as of caustic soda and most other sodium compounds. It is second only to lime and limestone in cheapness and general applicability as a base. It is used directly in making glass and after conversion into sodium hydroxide or other sodium compounds it is used in nearly all the chemical industries, especially in making soap, wood pulp, paper, dyes, explosives, bleach liquor, and cleansing preparations and in tanning.

MANUFACTURE.

GENERAL STATEMENT.

Sodium carbonate is present in the ashes of certain seaweeds and was long obtained from this source along the shores of France, Spain, and Great Britain. The origin of the name "soda ash" is doubtless thus explained. About 13 tons of ash is said to produce 1 ton of sodium carbonate and 30 pounds of iodine as a by-product. About 1775 the want of sodium carbonate was so greatly felt that the French Academy in that year offered a prize for the discovery of a profitable method of making it from common salt. This prize was won by Leblanc in 1791 for the process known by his name, which involves the preparation of sodium sulphate and its conversion into sodium carbonate. The Leblanc process was of great value to the chemical industries from the first quarter of the nineteenth century until recent years. It has been forced to give way gradually to the Solvay or ammonia process and to electrolytic methods. At present the ammonia process holds the field and increasing attention is being paid to natural soda, the utilization of which is determined very largely by costs of transportation. The Magadi deposit of natural soda in British East Africa has been estimated to contain 200,000,000 tons of soda, and enormous quantities of soda are known in certain areas in the western United States.

CONVERSION OF SODIUM SULPHATE INTO SODIUM CARBONATE.

Sodium sulphate, prepared either by heating salt with sulphuric acid or obtained in some other way, is heated with coal and limestone to form "black ash," the chemical changes being indicated by the following equation:

$$\underset{\text{sodium sulphate}}{2Na_2SO_4} + \underset{\text{calcium carbonate}}{3CaCO_3} + \underset{\text{carbon}}{9C} = \underset{\text{sodium carbonate}}{2Na_2CO_3} + \underset{\text{calcium oxide}}{CaO} + \underset{\text{calcium sulphide}}{2CaS} + \underset{\text{carbon monoxide}}{10CO}$$

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Upon lixiviation of the black ash the calcium compounds remain mostly insoluble and sodium carbonate goes into solution together with various impurities. The solution usually carries considerable sodium hydroxide and may be worked for either sodium hydroxide or sodium carbonate.

If sodium carbonate is to be prepared, the solution (specific gravity 1.28) is carbonated, filtered, and evaporated, yielding, if evaporated at boiling heat, crystals having the formula Na_2CO_3. The crystals are removed from the solution and heated to dry them completely. The product, "soda ash," carries 98 to 99 per cent sodium carbonate, 0.8 per cent sodium sulphate, 0.1 per cent sodium chloride, 0.1 per cent sodium sulphite or sodium thiosulphate, a little insoluble matter, and about 0.7 per cent moisture.

The "alkali waste" left after the lixiviation of the black ash for sodium carbonate and sodium hydroxide, which contains unchanged coal, calcium carbonate, and calcium sulphide, is now worked for sulphur by the Chance-Claus process. This process is summarized by the equation

$$\underset{\text{calcium sulphide}}{CaS} + \underset{\text{carbon dioxide}}{CO_2} + \underset{\text{water}}{H_2O} = \underset{\text{calcium carbonate}}{CaCO_3} + \underset{\text{hydrogen sulphide}}{H_2S}$$

The calcium carbonate thus produced can be recovered and used again, and the sulphur is recovered either as sulphur or ultimately as sulphuric acid.

In England, where the Leblanc process is still used to some extent, it is generally customary to convert the black ash liquor directly into sodium hydroxide instead of sodium carbonate. This is done as described under "Sodium hydroxide," page 185.

AMMONIA PROCESS.

The manufacture of sodium carbonate by the ammonia or Solvay process occupies to-day a very prominent position in the chemical industry and probably has only natural soda to fear in competition, although the electrolytic production of caustic soda is a factor to be reckoned with.

The reactions on which the process depends were known as early as 1852, but the mechanical details of treatment were first perfected by Ernest and Alfred Solvay in the late sixties and have been constantly improved. The process rests on the slight solubility of sodium bicarbonate in ordinary salt brine containing ammonium bicarbonate. The brine is saturated with ammonia and subjected to the action of carbon dioxide when, in consequence of the formation of the bicarbonate ion in solution, sodium bicarbonate is precipitated. The latter salt is removed by filtration and the mother liquor containing ammonium chloride is treated to recover ammonia. The sodium bicarbonate is calcined to produce soda ash and carbon dioxide which is again used in the process. The final product is "light" soda ash which for certain purposes is converted into "heavy" ash, comparable with Leblanc soda ash, which is preferred by the glass-making industry. The ammonia soda ash is of exceptional purity, running 99 to 99.7 per cent of sodium carbonate (Na_2CO_3).

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Plants for the manufacture of soda ash by the ammonia process must be situated near good supplies of salt and limestone in order to avoid excessive charges for transportation.

The principal waste product of the ammonia process is calcium chloride. Some of this is sold for use in manufacturing and as a dust-laying compound. Lime mud is sold for use as a fertilizer.

CRYOLITE PROCESS.

Sodium carbonate may be made from cryolite by heating it with limestone, extracting with water the sodium aluminate thus formed and decomposing the solution thus obtained with carbon dioxide. The sodium carbonate is finally separated in solution from the insoluble aluminum hydroxide precipitated by the treatment with carbon dioxide, and dehydrated to form soda ash. Soda ash made in this way is said to be very pure.

RECOVERY OF SODA ASH FROM SPENT PULP LIQUOR.

A number of pulp and paper mills that use the soda process of making fiber for the manufacture of paper recover sodium carbonate almost continuously from the spent liquor by evaporating the solutions and incinerating the residues, thus saving a quantity estimated at 80 to 90 per cent of the soda ash required. So far as known limestone and sodium sulphate are not added to increase the yield of soda ash in this procedure, though the Leblanc process would suggest the possibility.

ELECTROLYTIC PROCESS.

It is reported that the Hargreaves-Bird process of making sodium carbonate from salt by electrolysis is used in some of the plants of the West Virginia Pulp & Paper Co. and the New York-Pennsylvania Co., both companies at 200 Fifth Avenue, New York City. This process consists in carbonating the cathode solution in which caustic soda would otherwise be formed. The carbon dioxide is obtained from limekilns in which the lime used in causticizing the sodium carbonate is made. It is claimed that this process produces a carbonate solution that contains very little sodium chloride and can be causticized directly, whereas the usual electrolytic caustic solution must be freed from sodium chloride, also that the diaphragms last a long time, so that the process results in ultimate economy of operation.

The sodium carbonate reported as made by paper mills from spent liquor and by electrolysis in 1918 amounted to 39,277 short tons.

MONOHYDRATE AND SESQUICARBONATE.

When a solution of sodium carbonate evaporates above 35.1° C. the resulting crystals have the formula $Na_2CO_3.H_2O$. This salt is termed monohydrate or crystal sodium carbonate. It dissolves in water with the evolution of heat.

The sesquicarbonate ($Na_2CO_3NaHCO_3.2H_2O$), which when found in nature is known as trona, is prepared by allowing a solution containing proper proportions of sodium carbonate and sodium bicar-

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bonate to crystallize at a temperature above 35° C. It is said to possess the advantage of being neither efflorescent nor deliquescent.

The production of these two salts reported to the United States Geological Survey in 1918 was 22,678 short tons, valued at $482,958, compared with 55,035 short tons, valued at $1,262,875 in 1917.

SAL SODA.

Sal soda, hydrated sodium carbonate, washing soda, or crystal carbonate, having the chemical formula $Na_2CO_3.10H_2O$, is made from soda ash by dissolving it in water and allowing the solution to crystallize below 32° C.

The production of sal soda in the United States in 1918 was 82,465 short tons, valued at $2,020,271. The output for the years for which figures are available is shown in the following table:

Sal soda produced in the United States in certain years.[a]

	Quantity (short tons).	Value.		Quantity (short tons).	Value.
1899	63,249	$875,243	1914	106,591	$1,510,449
1904	59,548	831,869	1917	77,939	1,608,520
1909	86,644	1,156,882	1918	82,465	2,020,271

[a] The figures for 1899, 1904, 1909, and 1914 are taken from Chemicals and allied industries: Census of manufactures, p. 18, U. S. Dept. Commerce Bur. Census, 1918.

Sal soda is used in softening water and for many other purposes for which soda ash is used where purity is an essential requirement. It is also used in cleansing compounds or alone as washing soda.

The imports for consumption of sal soda into the United States, according to the records of the Department of Commerce, were practically negligible in both 1917 and 1918. The exports in 1918 amounted to 6,358 short tons, valued at $213,865.

During the last six months of 1917 there was exported 3,718 short tons of sal soda, valued at $97,772, of which more than half went to Canada and more than 25 per cent to Argentina.

The following firms reported the production of sal soda in 1918:

California Soap Co., 2437 Ninth Street east, Los Angeles, Calif.
Central Chemical Co., foot of Chapel Street, Newark, N. J.
Church & Dwight Co., 22 Cliff Street, New York, N. Y.
Citrus Soap Co., Ninth and K Streets, San Diego, Calif.
Columbia Chemical Co., Pittsburgh, Pa.
Columbus Crystal Co., 15 Arch Street, Newark, N. J.
Detroit Soda Products Co., 2595 Jefferson Street west, Detroit, Mich.
Fresno Soap Co., Fresno, Calif.
E. Griswold & Co., Sixth and Parker Streets, West Berkeley, Calif.
Humes Manufacturing Co., 110 Water Street, East Providence, R. I.
Iowa Soda Products Co., Detroit, Mich.
Los Angeles Soap Co., 633 First Street east, Los Angeles, Calif.
Mechling Bros. Manufacturing Co., Camden, N. J.
Morton Salt Co., 80 Jackson Boulevard east, Chicago, Ill.
Mount Hood Soap Co., 110 Fourth Street north, Portland, Oreg.
O'Neil Oil & Paint Co., Milwaukee, Wis.
Pennsylvania Salt Manufacturing Co., Philadelphia, Pa.
C. T. Perry & Co., Helena, Mont.
Phenix Supply Co., Atlanta, Ga.
John Reardon & Sons Co., Allston Street, Cambridge "A," Mass.

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Stauffer Chemical Co., 624 California Street, San Francisco, Calif.
Valley Chemical Manufacturing Co., 11 North Market Street, Chicago, Ill.
Vera Chemical Co., Hopkins and Villard Avenues, North Milwaukee, Wis.
Warnock & Ralston, 429 Second Street, Rock Island, Ill.
Western Alkali Refining Co., Omaha, Nebr.
John C. Wiarda & Co., Brooklyn, N. Y.

NATURAL SODA.

ANALYSES.

In the arid regions of western Nevada and southeastern California the soluble salts which accumulate by evaporation of surface waters in undrained basins in consequence of the deficient rainfall consist largely of sodium carbonate and sodium bicarbonate, together with sodium chloride and sodium sulphate. The largest accumulations are found in "playas" or "playa lakes," which are usually dry in summer but are covered with a few inches of water in winter. Many analyses of the incrustations deposited from playa lakes have been made. For examples the reader is referred to Clarke's "Data of geochemistry."[1] According to F. T. Shutt and E. A. Smith (Canadian Chemical Jour, vol. 2, p. 196, 1918) the data obtained in the study of the nature and concentration of alkali in semiarid districts of western Canada have aided in the classification of the areas into irrigable and nonirrigable lands.

The analyses of alkaline lake waters and incrustations given below are typical.

Analyses of alkaline lake waters.

	1	2	3	4	5	6	7
Cl	41.04	35.38	22.64	25.00	30.55	18.27	34.37
SO_4	5.25	10.50	12.47	9.74	.12	4.18	1.80
CO_3	14.28	7.79	19.76	19.58	20.42	35.57	15.33
HCO_3		8.10	5.93	4.29	1.72		9.03
Na	33.84	35.38	36.82	37.25	36.06	39.48	37.51
K	2.11	2.13	1.80	2.06	1.47	1.59	1.37
Ca	.25	.....	.04	.....	.03	Trace.	.....
Mg	2.28	.21	.10	.....	.33	Trace.	.....
SiO_2	.95	.25	.14	.20	.01	.62	.59
Al_2O_3	.....	.....	Trace.	.....	Trace.	.27	.....
B_4O_7	.....	.26	.30	1.88	4.78	.....	.....
Fe_2O_3	.....	.....	Trace.	.....	.....	Trace.	.....
Br	.....	.....	.....	.....	.03	.....	.....
PO_4	.....	.....	.....	.....	.02	.....	.....
Organic	.....	.....	.....	.....	4.46	.....	.....
NO_3	.....	.....	.....	.....	.....	.02	.....
	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Salinity, parts per million	3,486	113,700	51,170	118,830	76,560	16,633	39,172

1. Pyramid Lake, Nev. Mean of four concordant analyses by F. W. Clarke.
2. The large Soda Lake, Ragtown, Nev. U. S. Geol. Survey Bull, 9, p. 25, 1884. Sample from a depth of 30.5 meters. T. M. Chatard, analyst. An earlier analysis of Soda Lake by O. D. Allen is given in the U. S. Geol. Expl. 40th Par. Rept., vol. 2, p. 748, 1877. It is less complete than Chatard's, but otherwise is not very different. Specific gravity 1.101.
3. Mono Lake, Calif.: U. S. Geol. Survey Bull. 60, p. 53, 1890. Sample taken in 1882. Specific gravity 1.045. T. M. Chatard, analyst. An improbable analysis of Mono Lake water, by Winslow Anderson, is given in his Mineral springs and health resorts of California, p. 198, San Francisco, 1892. In it the calcium salts predominate over all others.
4. Owens Lake, Calif. Analysis in the laboratory of the U. S. Geol. Survey, 1913. Specific gravity 1.0977. W. B. Hicks, analyst. An analysis by J. G. Smith is given in U. S. Dept. Agr. Bull. 61, p. 80, 1914.
5. Borax Lake, Calif. Analysis by W. H. Melville, published by G. F. Becker in U. S. Geol. Survey Mon. 13, p. 265, 1888. In addition to the substances named in the table, the original residue contained 4.5 per cent of organic matter.
6. Summer Lake, Oreg. Analysis by W. Van Winkle, who cites two other analyses. Specific gravity 1.0162 at 15° C.
7. Abert Lake, Oreg. U. S. Geol. Survey Bull. 60, p. 55, 1890. T. M. Chatard, analyst. An earlier analysis by F. W. Taylor is not in accord with this. Specific gravity 1.03117 at 19.8° C.

[1] Clarke, F. W., U. S. Geol. Survey Bull. 616, p. 237, 1916.

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Analyses of alkaline lake waters.

	1	2	3	4	5	6
Cl	26.45	30.40	12.50	10.78	0.87	10.13
SO_4	7.38	8.62	15.47	16.62	61.55	52.47
CO_3	9.89	19.77	22.77	32.75	1.00	1.08
HCO_3	18.81		11.55		7.99	6.10
B_4O_7	.89	Present.				
Na	34.40	39.43	37.27	39.85	20.00	25.03
K	1.84	1.50			1.22	
Ca	None.	.03	Trace.		1.05	Trace.
Mg	.06	Trace.	.04		6.06	5.19
SiO_2	.28	.14	.40		.21	Trace.
Al_2O_3	None.	.10			.05	Trace.
Fe_2O_3	None.	Trace.				
PO_4		Trace.				
NO_3		.01				
	100.00	100.00	100.00	100.00	100.00	100.00
Salinity, parts per million	10,427	22,383	28,195	119,700	6,708	11,623

1. Harney Lake, Oreg. Analysis in the laboratory of the U. S. Geological Survey, George Steiger, analyst. Sample taken August 5, 1902. See U. S. Geol. Survey Water-Supply Paper 364, p. 34, 1914.
2. Harney Lake, Oreg. W. Van Winkle, analyst. Collected March 10, 1912. Specific gravity 1.0209.
3. Soap Lake, Wash.: U. S. Geol. Survey Bull. 113, p. 113, 1893. George Steiger, analyst.
4. Wilmington Lake, Wyo.: Wyoming Agr. Exper. Sta. Bull. 49, 1901. E. E. Slosson, analyst.
5. Lake De Smet, Wyo. Analysis in the laboratory of the U. S. Geol. Survey, W. T. Schaller, analyst. An analysis of its feeder, Shelle Creek, was also made. See U. S. Geol. Survey Water-Supply Paper 364, p. 17, 1914.
6. Devils Lake, N. Dak. North Dakota Univ. Quart. Jour., vol 1, p. 225, 1911. H. W. Daudt, analyst

Analyses of incrustations deposited from playa lakes in California, Nevada, and Wyoming.

	1	2	3	4	5
Na_2CO_3	72.69	75.95	45.05	44.25	30.62
$NaHCO_3$			34.66	34.90	30.09
Na_2SO_4	17.49	4.67	1.29	.99	25.75
NaCl	2.53	1.46	1.61	1.10	2.13
$NaNO_3$		12.98			
NaH_2PO_4		4.94			
$Na_2B_4O_7$	4.15				
KCl	1.18				
SiO_2	1.96				
Insoluble			.80	2.81	2.61
H_2O			16.19	15.95	9.01
	100.00	100.00	99.60	100.00	100.21

1. Soluble part from surface of playa, north arm of Old Walker Lake, Nev.: U. S. Geol. Survey Bull. 615, p. 237, 1916. T. M. Chatard, analyst.
2. From the Merced bottoms, Merced County, Cal.: California Univ. Exper. Sta. Rept., App., 1890. Analysis reported by E. W. Hilgard.
3. Big Soda Lake, Ragtown, Nev.: U. S. Geol. Expl. 40th Par. Rept., vol. 2, p. 748, 1877. O. D. Allen, analyst.
4. Little Soda Lake, Ragtown, Nev.: Idem, p. 759.
5. Surface soda from Carbon County, Wyo.: U. S. Geol. Survey Mineral Resources, 1885, p. 553, 1886. Analysis reported by J. D. Weeks.

The following analyses are given in Chatard's paper in Bulletin 60 of the United States Geological Survey:

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Analyses of incrustations deposited from alkaline waters.

	1	2	3	4	5	6	7	8
K_2SO_4	2.79	4.68	1.88					
Na_2SO_4	28.32	17.43	33.31	4.42	49.67	27.05	1.75	27.55
NaCl	2.11	38.01	24.51	7.24	20.88	59.32	85.27	18.47
Na_2CO_3	58.69	25.12	25.95	48.99	7.02	9.06	2.59	52.10
$NaHCO_3$	8.09	14.76	14.35	36.01	11.13			
$Na_2B_4O_7$				3.34	11.30	1.00		
KCl						1.39		
SiO_2						2.18	1.82	
H_2O							8.57	
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	98.12

1. Ruby Valley, Nev.: U. S. Geol. Expl. 40th Par. Rept., vol. 1, p. 503, 1877. R. W. Woodward, analyst.
2. Valley of Deep Creek, Utah: Idem, vol. 2, p. 474.
3. Antelope Valley, Nev.: Idem, vol. 2, p. 541.
4. Humboldt Valley, Nev.: Idem, vol. 2, p. 594.
5. Brown Station, Humboldt Lake, Nev.: Idem, vol. 2, p. 744.
6. Soluble part of incrustation near Black Rock Point, Black Rock Desert: U. S. Geol. Survey Mon. 11, p. 231, 1885. T. M. Chatard, analyst.
7. Quinn's River salts: U. S. Geol. Expl. 40th Par. Rept., vol. 2, p. 791, 1877. O. D. Allen, analyst.
8. Hardin City salts: Idem, p. 792. O. D. Allen, analyst.

UTILIZATION OF NATURAL SODA IN WESTERN STATES.

LOCALITIES OF COMMERCIAL PRODUCTION.

The United States Geological Survey long ago called attention to the value of the natural soda in the Western States.[1] The deposits have been worked commercially in a number of places, at first for local consumption and later for wider use as transportation facilities became available. Natural soda has been suggested as cheap and effective in all processes where purity is not a prime requisite, as in treating ores by flotation. Moreover, the extraction of potassium salts, principally potassium chloride and potassium sulphate, from natural brines and lake waters, has recently been carried out conjointly with the production of sodium salts, especially sodium chloride, sodium bicarbonate, and sodium tetraborate, and the methods of separating these various salts are being studied and improved constantly.

The firm of Huff, Tebbe & Weed, of Dunsmuir, Calif., shipped some crude natural soda to San Francisco in 1917, where it was refined and placed on the market by the Soda Refining Co., of San Francisco.

Natural soda has been produced commercially at the following places:

"Union Pacific Lakes,"[2] 13 miles south of Laramie, Wyo.
"Downey" lakes, 18 miles southwest of Laramie, Wyo.
Soda lakes, Ragtown, Nev.
Long Valley, southeast of Mono Lake, Calif.
Owens Lake, Inyo County, Calif.
Grant County, Wash.
Green River, Wyo.
Vernon, Calif.
Dorris, Calif.
Antioch, Nebr.
North of Clinton, British Columbia.[3]

[1] Chatard, T. M., Natural soda—its occurrence and utilization: U. S. Geol. Survey Bull. 60, pp. 27–101, 1890.
[2] Weeks, J. D., Glass materials: U. S. Geol. Survey Mineral Resources, 1885, p. 550–552, 1886.
[3] Canadian Chem Jour., vol. 3, p. 182, 1919.

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Chatard [1] pointed out the favorable conditions that exist at Owens Lake for the production of sodium carbonate and studied the process of fractional crystallization of the dissolved material. From his results it appears that the first crop of crystals consists largely of trona ($Na_2CO_3NaHCO_3.2H_2O$). The companies now producing soda at Owens Lake, however, report soda ash as their principal product.

The original operator at Owens Lake was the Inyo Development Co. The plant of this company north of Keeler, with about 3,000 acres of land, has now been turned over to the California Alkali Co., which constructed a new plant at Cartago in 1917. The latter company worked over some low-grade sodium carbonate in 1918 that had formed from seepage from the evaporating vats of the Inyo Development Co.

The usual process at Owens Lake consists in evaporation of the lake water in open vats until a deposit of trona is formed. The trona is then heated to form soda ash. Another process consists in evaporating the water and then introducing carbon dioxide to precipitate sodium bicarbonate.

The Natural Soda Products Co., of Keeler, Calif., reported the production of both sodium carbonate and sodium bicarbonate in 1918, the latter, however, as crude material carrying 76 per cent $NaHCO_3$.

A new plant is being constructed by the Soda Products Corporation of California, 308 Call Building, San Francisco, for making soda from the water of Owens Lake. This plant had not been completed, nor had any soda been produced up to May, 1919.

The Western Alkali Refining Co., 820 World Herald Building, Omaha, Nebr., reported the production in 1918 of sodium carbonate in the form of sal soda at its plant at East Omaha, Nebr. This salt was obtained in purifying crude potash salts produced at Antioch and Hoffland, Nebr., and therefore represents natural soda. The crude potash salts are said to run about 60 per cent sodium carbonate.

A new use for natural soda has recently been proposed in the manufacture of so-called mineral soap, which is made from flocculated clay, oil, and sal soda.

FOREIGN DEPOSITS OF NATURAL SODA.

Lake Magadi.—The Magadi Soda Co. (Ltd.), Kajrado, British East Africa, has been formed to develop the deposit of natural soda covering about 6 square miles, known as Lake Magadi, and the material is to be refined in England. The deposit is said to contain at least 200,000,000 tons of soda.

Pretoria.—At what is called the Salt Pan in the Pretoria district, South Africa, natural soda is found in a deep crater-like depression and extends to a considerable depth. The material consists partly of trona and partly of mud impregnated with salt and soda, from which the soda has to be extracted and recrystallized. Soda also occurs in this district as an efflorescence resulting from the evaporation of solutions derived in the weathering of granite.[2] The reported production of soda in the Union of South Africa in 1918 was valued at about $47,000.[3]

[1] Chatard, T. M., op. cit., p. 63.
[2] South Africa Min. Jour., vol. 28, pt. 1, p. 512, 1919.
[3] Idem, vol. 28, pt. 3, p. 11, 1919.

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PATENTS FOR TREATING ALKALI BRINES.

That the separation and utilization of the several salts occurring in the deposits of natural soda in the Western States offer interesting problems in chemical engineering is shown by the patents issued in recent years.

United States patent 1254521, issued January 22, 1918, to J. R. MacMillan, describes the separation of sodium and potassium carbonates. The solution is evaporated to a specific gravity of 1.39, treated with carbon dioxide to separate sodium bicarbonate, and then cooled to 0° to cause deposition of potassium bicarbonate. After evaporating the mother liquor the process is repeated.

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1902. BAILEY, G. E., The saline deposits of California: California State Min. Bur. Bull. 24, 216 pp.

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KINDLE, E. M., Salt resources of the Watkins Glen district, N. Y.: U. S. Geol. Survey Bull. 260, pp. 567–572.

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1909. ARNOLD, RALPH, and JOHNSON, H. R., Sodium sulphate in Soda Lake, Carrizo Plain, San Luis Obispo County, Calif.: U. S. Geol. Survey Bull. 380, pp. 369–372.

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SODIUM CHLORATE.

Sodium chlorate ($NaClO_3$) is prepared from sodium carbonate and chlorine or from sodium hydroxide and chlorine or by the electrolysis of hot sodium chloride brine. This salt has recently supplanted potassium chlorate to a considerable extent in medicine and is also used in making dyes, matches, and high explosives.

The production of sodium chlorate in the United States in 1918 is withheld, as there were only two producers. The figures have, however, been combined with those for sodium perborate which also could not be published separately. The total production of these two salts was 2,413 short tons, valued at $1,004,250, against 2,915 tons, valued at $1,333,426, in 1917.

Imports of sodium chlorate in 1918 were 22 short tons, a slight increase over those of 1917.

Sodium chlorate was produced in 1918 by the North American Chemical Co., Bay City, Mich., and the Oldbury Electro Chemical Co., Niagara Falls, N. Y.

SODIUM CHLORIDE (COMMON SALT).

The production and utilization of sodium chloride (NaCl) are given in full in the chapter on salt in Mineral Resources by R. W. Stone,[1] of the United States Geological Survey, whose figures for the production in 1918 are 2,830,600 short tons in brine, 1,683,941 short tons of rock salt, and 2,724,203 short tons of evaporated salt, valued at $1,245,265, $5,684,661, and $20,010,435, respectively. The corresponding figures for 1917 are shown in the table on page 161.

The known production of sodium carbonate from salt and limestone and that of caustic soda from salt by electrolysis show that approximately 2,260,000 short tons of sodium chloride was used for making

[1] Salt, bromine, and calcium chloride: U. S. Geol. Survey Mineral Resources, 1918, pt. 2, pp. 119–121, 1919.

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sodium carbonate in the United States in 1918, and that about 165,000 tons of salt was electrolyzed for the production of caustic soda, chlorine, and other products in 1918. In addition, at least 85,000 short tons must have been used in making hydrochloric acid and other sodium compounds.

SODIUM CHROMATE.

(See Sodium bichromate, p. 169.)

SODIUM CYANIDE.

Since the war created a scarcity of potassium cyanide sodium cyanide has been largely substituted for it in the cyanide process of recovering gold and silver from their ores. Sodium cyanide is manufactured by the Niagara Electro Chemical Co., Niagara Falls, N. Y.

In order not to reveal the production of individual firms the figures for the production of sodium cyanide in 1917 have been combined with those for sodium iodide and sodium peroxide. The combined production of these salts in 1918 was 9,086 short tons, valued at $5,427,240, compared with 9,694 short tons, valued at $6,133,000, in 1917.

Analysts are accustomed to determine only the cyanide radical in cyanides, as their value depends on the cyanogen content, but it has long been customary to report the cyanogen as potassium cyanide. As pure potassium cyanide contains 40 per cent and sodium cyanide 53 per cent of cyanogen it follows that sodium cyanide may be reported as carrying more than 100 per cent of potassium cyanide. This also allows very impure sodium cyanide to be sold as 97 or 98 per cent potassium cyanide, but, needless to say, the potassium salt is not now largely used. Recently sodium cyanide has been selling on the basis of its actual sodium cyanide content, the highest grade being 96 to 98 per cent sodium cyanide (NaCN), or cyanogen 51 to 52 per cent. The old "98 per cent KCN" used to run about 39 per cent of cyanogen. Four pounds of sodium cyanide are therefore chemically equivalent as a solvent to about 5 pounds of the old "KCN."

Sodium cyanide is widely used as a solvent of the precious metals in metallurgy and in electroplating, and also as a source of hydrocyanic acid for fumigation in orchards where gaseous hydrocyanic acid is applied as an insecticide to individual trees, which are covered with tents during the process. The great production of gold from low-grade properties in the last two decades, beginning in the Transvaal and extending all over the world is largely due to the "cyanide process." The effective solution in the cyanide process contains usually only about 0.20 per cent of sodium cyanide. Sodium cyanide is also used in case hardening and in synthesizing organic acids.

Sodium cyanide may be made from ferrocyanide or sulphocyanide obtained from gas works, coke works, or beet-sugar waste. It results, for example, from heating sodium ferrocyanide with sodium according to the reaction $Na_4Fe(CN)_6 + 2Na = 6NaCN + Fe$. The process is carried out in iron crucibles, the melted cyanide being

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filtered through spongy iron by means of compressed air. When made in this way the only impurities are small quantities of sodium cyanate, sodium carbonate, and sodium hydroxide.[1]

The Castner process of making sodium cyanide consists in heating together at the proper temperature sodium and ammonia, and finally also charcoal in furnaces especially designed for that purpose. The intermediate products are sodamide ($NaNH_2$) and sodium cyanamide (Na_2CN_2). The final result is summarized by the equation $2NH_3+2Na+2C=2NaCN+3H_2$.

Sodium cyanide may be made by heating commercial calcium cyanamide ($CaCN_2+C$) for a few minutes with common salt at about 940° C. out of contact with air and then quickly cooling the mixture. The product contains from 20 to 30 per cent of sodium cyanide and may be used directly for the extraction of gold.

The manufacture of cyanides directly from atmospheric nitrogen has been the subject of much study and now offers promise of commercial development. The Bucher process consists in heating soda ash and powdered coke with iron ore in a furnace through which air is passed. This process is now under investigation by Government agencies.

United States patent 1256272, issued February 12, 1918, to P. A. Starke, describes a method of making cyanides by passing natural gas and ammonia over a mixture of soda ash, magnesia, and iron heated to 400–800°. The manufacture of cyanides from calcium cyanamide is described in United States patents 1277989 and 1277900, issued to H. Freeman, September 3, 1918. According to patent 1262057, issued April 7, 1918, to A. Kaufman, a briquet with fused outer coating of sodium cyanide is effective in the preservation of sodium cyanide.

A paper on the war and the nitrogen industry by W. S. Landis appeared in Chemical and Metallurgical Engineering, volume 19, page 828, 1918.

SODIUM FERROCYANIDE.

Sodium ferrocyanide, yellow prussiate of sodium ($Na_4Fe(CN)_6.10H_2O$), is used in making certain blue colors, such as Prussian blue, Chinese blue, and Paris blue, which are employed extensively in dyeing textiles and in making paint and printing ink. Practically all ferrocyanide is now made from material obtained in purifying coal gas. Such material is mixed with lime, and the soluble calcium ferrocyanide is leached out and subsequently converted into sodium ferrocyanide by treatment with sodium carbonate.

Before the war a considerable quantity of this salt was imported from England and Germany, but the restriction of imports during the war resulted in a greatly increased domestic production, owing to the decreased importation of ferrocyanide, as well as to the supplanting of potassium ferrocyanide by sodium ferrocyanide on account of the scarcity of potash.

The quantity of sodium ferrocyanide marketed in the United States in 1918 was 4,525 short tons, valued at $2,690,110. This was a small increase in value over the corresponding figures for 1917,

[1] Martin, Geoffrey, and Barbour, William, Industrial nitrogen compounds and explosives, p. 72, New York, 1917.

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which were 4,173 short tons, valued at $2,577,667. The domestic production in both 1917 and 1918 was much larger than that of any previous year. Imports of sodium ferrocyanide have been decreasing each year since 1914, when they amounted to 1,148 short tons, valued at $171,834.

Prices obtained for sodium ferrocyanide in 1918 were notably higher than the average of 1917, but they have since fallen considerably below those of 1917. It is understood that the producers in this country are now in a position to supply all domestic requirements.

In British patent 109254, issued to E. V. Espenhahn, July 25, 1917, it is proposed to wash gases containing cyanogen compounds with a hot concentrated solution of sodium carbonate containing ferrous sulphide or ferrous sodium ferrocyanide in suspension. The washing liquor after separating the insoluble matter is cooled to crystallize $Na_4Fe(CN)_6.10H_2O$.

In United States patent 1252741, issued January 8, 1918, to A. R. Tillinghast the gases are scrubbed with a suspension of ferrous carbonate in sodium carbonate, the resulting solution is treated with milk of lime to convert insoluble ferrocyanides into soluble ferrocyanides and the sodium ferrocyanide is crystallized after filtration from insoluble matter. United States patent 1252742 describes the treatment of the mother liquor with ferrous sulphate to form a fresh absorbing medium.

Sodium ferrocyanide was manufactured in 1918 by

Citizens Gas Co., Indianapolis, Ind.
Henry Bower Chemical Manufacturing Co., Philadelphia, Pa.
Morris Herrman & Co., Port Elizabeth, N. J.
Penman-Littlehales Co., Syracuse, N. Y.
Portland Gas & Coke Co., Portland, Oreg.
Seattle Lighting Co., Seattle, Wash.
Semet-Solvay Co., Syracuse, N. Y.
Worcester Gas Light Co., Worcester, Mass.

SODIUM FLUORIDE.

Sodium fluoride (NaF) is made by treating cryolite with NaOH, the NaF being sparingly soluble. It may also be made from hydrofluoric acid and soda ash. This salt is used in making enamels, and as a flux and insecticide. Sodium fluosilicate or silicofluoride is also used in making enamels. United States patent 1247619, issued November 27, 1918, to J. S. Beckett, describes the manufacture of sodium fluosilicate from phosphate rock containing fluorides.

The reported production of sodium fluoride, acid sodium fluoride, and sodium fluosilicate in the United States in 1918 amounted to 1,228 short tons, valued at $281,264, compared with 1,424 short tons, valued at $397,305, in 1917.

Sodium fluoride is produced by the General Chemical Co., New York, N. Y., the Harshaw, Fuller & Goodwin Co., 720 Electric Building, Cleveland, Ohio, and John C. Wiarda & Co., Brooklyn, N. Y. The Harshaw, Fuller & Goodwin Co. also makes acid sodium fluoride. The production of sodium fluosilicate in 1918 was reported by the Baugh Chemical Co., 25 South Calvert Street, Baltimore, Md., the Davison Chemical Co., Baltimore, Md., the Virginia-Carolina Chemical Co., Richmond, Va., and the Armour Fertilizer Works, Chicago, Ill.

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SODIUM HYDROXIDE.

Sodium hydroxide, or caustic soda (NaOH; theoretically Na_2O 77.48 per cent, H_2O 22.52 per cent), is a base and not a salt of sodium.

Production.—The total production of caustic soda in the United States in 1918, as reported by the producers, and not including that made in soap works, amounted to 513,363 short tons, valued at $31,854,470, as compared with 488,056 short tons, valued at $29,402,689, in 1917. Of this quantity about 85 per cent, or 434,156 short tons, valued at $26,776,579, represents sales, the remainder, 79,207 short tons, valued at $5,077,891, was consumed by the producers in their own plants.

The production of caustic soda may be further classified according to the method of manufacture. In 1918 about 72 per cent of the production, or 370,591 short tons, was made from sodium carbonate and lime, and 28 per cent, or 142,772 short tons, was made by the electrolysis of sodium chloride. The average value of that made in the first way was $59 a ton, as reported by the producers, and of that made by electrolysis $64 a ton. Electrolytic caustic, however, varies widely in value according to its purity, method of preparation, and the purpose for which it is made.

Imports and exports.—The imports of caustic soda for consumption in the United States dropped from 146,236 pounds, valued at $17,773 in 1917, to only 2,002 pounds, valued at $193, in 1918, according to statistics compiled by the Department of Commerce. The exports in 1918 were 48,689 short tons, valued at $5,602,813, of which Japan, Brazil, Canada, Cuba, and Argentina received the largest quantities, in decreasing order of quantity exported to each. This compares with exports for the last six months of 1917 of 44,997 short tons, valued at $5,832,598, going principally to Japan, Italy, Brazil, Argentina, Canada, Mexico, and France.

The need of other countries for caustic soda heretofore imported is leading to many proposals for the construction of plants.

A plant has been constructed by the Brunner, Mond Co. (Ltd.), of Canada, for the manufacture of soda ash and caustic soda at Amherstburg, Ontario, where salt and limestone occur close together. Caustic soda is now manufactured by the electrolytic process by the Canadian Salt Co. at its works at Sandwich, Ontario.

It is understood that plants for the electrolytic production of caustic soda have been begun recently in Peru, Brazil, China, and Japan. The Brazilian Government has offered pecuniary assistance to the first three firms beginning operations.

Manufacture.—Sodium hydroxide may be made from the black ash liquor of the Leblanc process (p. 173) by treating the diluted liquor with lime at a boiling temperature. Calcium carbonate settles out and the resulting lye is purified by evaporation and removal of the salts which separate as the concentration proceeds until finally fused NaOH is obtained. The last step in the purification consists in the addition of a very little niter, which decomposes sulphides and cyanides. Sodium hydroxide is made in exactly the same way from sodium carbonate prepared by the ammonia process, but it does not then require the treatment with niter. The spent causticizing mud, after being thoroughly separated from the liquor, is generally treated in rotary kilns to recover the lime.

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Many pulp and paper mills make sodium hydroxide from lime and soda ash in their own plant. The recovery of the soda ash has been described under sodium carbonate (p. 174).

At the mill of the Kingsport Pulp Corporation, Kingsport, Tenn., a continuous process of causticizing soda ash with lime was tried over a period of several months. It was stated that the total cost of producing caustic soda, exclusive of the cost of raw materials, was approximately 47 cents a short ton of 100 per cent sodium hydroxide, with labor at 30 cents an hour and power at 2 cents a kilowatt hour.

Much caustic soda is now made by the electrolysis of sodium chloride in solution, and many types of cells have been used or proposed to keep the anodic and cathodic products separated. Chlorine is produced at the anode and either sodium hydroxide, sodium carbonate, or an alloy, or an amalgam of sodium at the cathode. For some purposes the anodic and cathodic products of electrolysis are allowed to mix and the resulting solution is used directly in bleaching. The anodes are generally of graphite. The chlorine produced at the anode is either liquefied or converted into bleaching powder, sulphur monochloride, carbon tetrachloride, chloroform, or other chlorine compounds used in making dyes, war gases, benzoic acid, and other compounds. Electrolytic caustic soda can compete with the Solvay soda only by utilizing the chlorine in some way.

In the Castner-Kellner process the cathode is mercury, and the cell consists of three compartments so arranged that a weak sodium amalgam is no sooner formed in the middle compartment containing a solution of salt than it passes into one of the outer compartments containing water, which reacts with the amalgam under the influence of the electric current to form a dilute solution of sodium hydroxide.

The Townsend cell relies on the separation of caustic soda solution by gravity through a heavy oil, into which drops of the caustic solution are carried from the cathode by means of a slight flow of the brine through the diaphragm adjacent to the cathode.

The Allen-Moore cell relies on a circulation of the brine. The framework of these cells is of concrete and the construction permits a change of diaphragms without dismantling the whole cell. The voltage drop per cell varies from 3.2 to 3.5 volts and a current density of about 42 amperes per square foot is employed

The Nelson cell maintains an atmosphere of steam in the cathode compartment which regulates the flow of brine and decreases the resistance of the cell.

The Hargreaves-Bird cell, which has been mentioned under sodium carbonate (p. 174) consists of a diaphragm immersed on the anode side, the diaphragm and cathode being exposed to an atmosphere of steam and carbon dioxide whereby the sodium salts are washed off in the form of sodium carbonate solution. The efficiency of this cell is said to be greater when producing sodium carbonate than when producing caustic soda and the diaphragms last longer

Other cells in use or under investigation are the Billeter, Wheeler, and Gibbs cells.

The Loewig process of making sodium hydroxide consists in heating soda ash with ferric oxide to form sodium ferrite and carbon dioxide, which is completely volatilized. The sodium ferrite is afterward decomposed by water to from a concentrated solution of sodium hydroxide, specific gravity 1.49, and iron oxide, which is used over again.

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A powder for generating caustic soda and adapted for transfer or storage in boxes or bags has been described; it consists of a mixture of dry slacked lime with from three to five parts of dry sodium carbonate.

Uses.—Sodium hydroxide is used in large quantities in making soap, lye, and pulp or fiber for making paper. It is also used in mercerizing cotton, in purifying oils and fats, in refining petroleum, reclaiming rubber, in making dyes and phenol (which is used in the manufacture of the picrates for explosives), in making pigments, cleaning metals for electroplating, and in the chemical trade.

The need of the Government for caustic soda in 1917 and 1918 led to a regulation of exports by means of licenses. All restrictions were finally removed after the armistice was signed, however, and the quantity of caustic soda remaining on hand was so small that its disposition was without effect on the market.

Producers.—The following list gives the producers of caustic soda in 1918, exclusive of soap makers:

Baltimore Copper Smelting & Rolling Co., Baltimore, Md.
Brown & Co., 404 Commercial Street, Portland, Me.
Champion Fibre Co., Canton, N. C.
Columbia Chemical Co., Pittsburgh, Pa.
Diamond Alkali Co., Pittsburgh, Pa.
Dill & Collins Co., Sixth and Cherry Streets, Philadelphia, Pa.
Dow Chemical Co., Midland, Mich.
E. I. du Pont de Nemours & Co., Wilmington, Del.
Eastern Electro-Chemical Co., Bangor, Me.
Edgewood Arsenal, Edgewood, Md.
Fields Point Manufacturing Co., Box 4, Edgewood Station, Providence, R. I.
Great Western Electro-Chemical Co., Holbrook Building, San Francisco, Calif.
Gulf Refining Co., Port Arthur, Tex.
Hamersley Manufacturing Co., Garfield, N. J.
Hooker Electro-Chemical Co., Niagara Falls, N. Y.
Huron Milling Co., Harbor Beach, Mich.
Isco Chemical Co., Niagara Falls, N. Y.
Jessup & Moore Paper Co., Philadelphia, Pa.
Kimberly-Clark Co., Neenah, Wis.
Mathieson Alkali Works, Providence, R. I.
Mead Pulp & Paper Co., Dayton, Ohio.
Miami Paper Co., West Carrollton, Ohio.
Michigan Alkali Co., Detroit, Mich.
Michigan Electro-Chemical Co., Menominee, Mich.
Niagara Alkali Co., Niagara Falls, N. Y.
Niagara Smelting Corporation, Niagara Falls, N. Y.
Oxford Paper Co., 200 Fifth Street, New York, N. Y.
Pennsylvania Salt Manufacturing Co., Philadelphia, Pa.
Penobscot Chemical Fibre Co., 49 Federal Street, Boston, Mass.
Republic Chemical Co., Pittsburgh, Pa.
Rub No More Co., Dorenger Avenue, Fort Wayne, Ind.
Solvay Process Co., Syracuse, N. Y.
Vulcan Detinning Co., Sewaren, N. J.
Warner Chemical Co., 52 Vanderbilt Avenue, New York, N. Y.
Warner-Klipstein Chemical Co., 52 Vanderbilt Avenue, New York, N. Y.
S. D. Warren Co., Boston, Mass.
West Virginia Pulp & Paper Co., 200 Fifth Avenue, New York, N. Y.

SODIUM IODIDE.

Sodium iodide (NaI) may be prepared in several ways, as, for example, from caustic soda and iodine. It is used in photography, in analytical chemistry, and in medicine, especially for making solutions of iodine. It is said that this salt may be employed in

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medicine with fully as favorable results as are obtained from potassium iodide.

The production of sodium iodide in the United States in 1918 has been given with that of sodium cyanide and sodium peroxide. It is manufactured by McKesson & Robbins (Inc.), 91 Fulton Street, New York, N. Y.; the Mallinckrodt Chemical Works, St. Louis, Mo.; the Powers-Weightman-Rosengarten Co., Philadelphia, Pa., and E. R. Squibb & Sons, New York, N. Y.

SODIUM NITRATE.

Data on the occurrence and production of sodium nitrate ($NaNO_3$) are given in a previous volume of Mineral Resources.[1] As is well known, most of the sodium nitrate used in the United States is imported from South America, principally from Chile. The imports for consumption in 1916 were 1,275,962 short tons, valued at $38,131,364; in 1917 1,728,390 short tons, valued at $60,727,100; and in 1918 2,069,379 short tons, valued at $90,216,935, according to records of the Department of Commerce.

Refined sodium nitrate was produced in 1918 by E. R. Squibb & Sons, New York, N. Y., and the Mallinckrodt Chemical Works, St. Louis, Mo.

Many samples of nitrate-bearing material have been examined by the United States Geological Survey from time to time, but, although the percentages of nitrate have at times been very promising, the material has so far either not been found in quantity in any given locality or it has been found to be so widely disseminated in lavas or tuffs as to make its successful commercial treatment doubtful.

SODIUM NITRITE.

Sodium nitrite ($NaNO_2$) is made by heating sodium nitrate with lead. The product is extracted with water and the solution is allowed to crystallize, when anhydrous sodium nitrite separates. It is used in making coal-tar dyes and as a chemical reagent. The production reported for 1918 was 1,701 short tons, valued at $609,779, compared with 861 short tons, valued at $840,145, in 1917.

The imports for consumption in 1918 were 1,429 short tons, valued at $289,182, compared with 4,384 tons, valued at $349,111, in 1917.

Sodium nitrite was manufactured in 1918 by the following firms:

Atlas Powder Co., Wilmington, Del.
E. I. du Pont de Nemours & Co., Wilmington, Del.
Harshaw-Fuller & Goodwin Co., 720 Electric Building, Cleveland, Ohio.
Merrimac Chemical Co., 148 State Street, Boston, Mass.
Semet-Solvay Co., Syracuse, N. Y.

The American Nitrogen Products Co., Seattle, Wash., did not report any sodium nitrite in 1918, but stated that experimental work was being carried on.

SODIUM PERCARBONATE.

United States patent 1263258, issued April 16, 1918, to O. Liebknecht, claims that sodium percarbonate is precipitated from a solution containing sodium carbonate and hydrogen peroxide by the addition of a large quantity of sodium chloride.

No production of this salt was reported to the United States Geological Survey for 1918.

[1] Phalen, W. C., Potash salts: U. S. Geol. Survey Mineral Resources, 1914, pt. 2, p. 18, 1916.

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SODIUM PERBORATE.

Sodium perborate, which is made by suspending borax in a solution of sodium carbonate that is being electrolyzed, is used in laundry work, in bleaching cotton and linen, and for hygienic purposes. It is an oxidizing agent. According to the mode of preparation, sodium perborate has the formula $Na_2B_4O_8.10H_2O$ or $NaBO_3.4H_2O$. The addition of sulphuric acid to a solution of sodium perborate sets free hydrogen peroxide, or the same result can be obtained by merely heating the solution; in fact, in bleaching, sodium phosphate is often used with sodium perborate to maintain an alkaline solution.

Figures for the production of this salt have been combined with those for the production of sodium chlorate, the total for 1918 being 2,413 short tons, valued at $1,004,250, compared with 2,915 short tons, valued at $1,333,426, in 1917.

In United States patent 1268369, dated June 4, 1918, and issued to O. Liebknecht, it is claimed that a mixture of sal soda and sodium perborate accelerates the formation of more perborate in the electrolysis of an alkaline solution containing borax.

Sodium perborate was manufactured in 1918 by Roessler & Hasslacher Chemical Co., 100 William Street, New York, N. Y.

SODIUM PERMANGANATE.

Sodium permanganate ($NaMnO_4$) is made by the electrolytic oxidation of sodium manganate. It is used where potassium permanganate was formerly employed. The production of this salt, which was made in 1918 by the Kalbfleisch Corporation, Brooklyn, N. Y., is included with miscellaneous salts. Some sodium permanganate is made as an intermediate product in the process of manufacturing potassium permanganate.

SODIUM PEROXIDE.

Sodium peroxide is manufactured by the Niagara Electro Chemical Co., Niagara Falls, N. Y. It is made by burning metallic sodium in an excess of air or oxygen. It is used in chemical analysis, especially in decomposing pyrite and chromite, and in bleaching, also for generating oxygen in hospitals, submarines, and mine-rescue apparatus, and in making hydrogen peroxide. When pressed into blocks with a little nickel sulphate, copper sulphate, or potassium permanganate, sodium peroxide may be used to generate oxygen merely through the action of water.

In order not to reveal the output of single producers the production of sodium peroxide in 1918 has been added to that of sodium cyanide and sodium iodide, the combined figures being 9,086 short tons, valued at $5,427,240, compared with 9,694 short tons, valued at $6,133,000, in 1917.

SODIUM PHOSPHATE.

Sodium phosphate ($Na_2HPO_4.12H_2O$) is one of several different phosphates, all of which are derived originally from phosphate rock. The rock is first treated with sulphuric acid, the solution of phosphoric acid thus obtained is separated from the insoluble calcium sulphate and neutralized with soda ash, and this solution is allowed to crystallize.

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Sodium phosphate is used in the textile industry, as a water softener, in making baking powder, and in the pharmaceutical trade.

Sodium phosphate was manufactured in 1918 by the following firms:

Armour Fertilizer Works, Chicago, Ill.
Bowker Chemical Co., 2 Rector Street, New York, N. Y.
Burns Manufacturing Co., 15 Beaver Street, New York, N. Y.
Grasselli Chemical Co., Cleveland, Ohio.
Victor Chemical Works, Fisher Building, Chicago, Ill.
Warner Chemical Co., 52 Vanderbilt Avenue, New York, N. Y.

Trisodium phosphate was manufactured by Bowker Chemical Co., Grasselli Chemical Co., and Burns Manufacturing Co.

The total production of all varieties of sodium phosphate, including monosodium phosphate, disodium phosphate, and trisodium phosphate, in the United States in 1918 amounted to 15,620 short tons, valued at $1,427,947. The following table contains such figures as are available for the annual production of sodium phosphate to date:

Sodium phosphate produced in the United States, 1899–1918.[a]

	Quantity (short tons).	Value.		Quantity (short tons).	Value.
1899	2,340	$155,989	1914	15,397	$853,528
1904	4,830	244,373	1917	13,305	711,283
1909	12,290	540,282	1918	15,620	1,427,947

[a] The figures for the years 1899, 1904, 1909, and 1914 are from Chemicals and allied industries: Census of Manufactures, p. 18, U. S. Dept. Commerce Bur. Census, 1918.

SODIUM SILICATE.

Sodium silicate or water glass, as manufactured commercially, is not a definite chemical compound. The bulk of the commercial product is of 1.38 specific gravity, but it ranges from 1.34 to 1.91. The molecular ratio of SiO_2 to Na_2O in these different grades varies from about 1 to 4, being lowest in the most concentrated solutions.

The production of sodium silicate for the calendar year 1918 amounted to 317,161 short tons, valued at $5,870,973, which compares with 254,011 short tons, valued at $3,317,547, in 1917. The last previously reported production was that given by the Bureau of the Census for 1914, which amounted to 169,049 short tons, valued at $1,648,854, a great advance over all previous years. The price of the 40° B. strength f. o. b. tank cars rose from $12 a ton during the first quarter of 1917 to $17 in the last quarter, and advanced to $19 by March, 1918. Recent prices for the 60° B. strength have been steady between 3 and 4 cents a pound.

Imports of sodium silicate have decreased each year since 1915. Exports, however, during the last six months of 1917 amounted to 7,275 short tons, valued at $216,828, and in 1918 they amounted to 14,125 short tons, valued at $404,796, according to figures furnished by the Department of Commerce.

The original use of sodium silicate in this country, and the use still requiring the largest quantity, is as an ingredient of household and laundry soap. Other important uses are as an adhesive in the manufacture of corrugated and combined fiber shipping cases, wall

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board, veneer panels, asbestos products, and in sealing shipping cases; as a binder in abrasive wheels, and in acid-proof and heat-resisting cements; in sizing barrels, grease-proofing paper board, paper sizing, egg preserving, silk weighting, and as a boiler compound.

Sodium silicate was manufactured by the following firms in 1918:

L. Feuchtwanger, Little Ferry, N. J.
Frohman Chemical Co., Sandusky, Ohio.
General Chemical Co., New York, N. Y.
Grasselli Chemical Co., Cleveland, Ohio.
Mechling Bros. Manufacturing Co., Camden, N. J.
Philadelphia Quartz Co., 121 Third Street south, Philadelphia, Pa.
Philadelphia Quartz Co. of California, Berkeley, Calif.
Procter & Gamble Co., Cincinnati, Ohio.
Valley Chemical & Manufacturing Co., 111 North Market Street, Chicago, Ill.

SODIUM SULPHATE.

SALT CAKE.

Sodium sulphate (Na_2SO_4) is obtained in large quantities in the manufacture of hydrochloric acid from sodium chloride, either with the aid of niter cake, of sulphuric acid, or by Hargreave's process from sulphur dioxide, air, and steam. The product is generally termed "salt cake."

The salt cake marketed in the United States in 1918 amounted to 141,054 short tons, valued at $2,844,897, a slight decrease in quantity and value from the output for 1917. The Bureau of the Census reported an output of 90,442 tons of salt cake, valued at $841,887 for the year 1914.

Uses.—Sodium sulphate as salt cake is used in making plate glass, window glass, and bottles. Glassmaker's salt cake should be very low in iron, sulphuric acid, sodium chloride, and calcium sulphate. Hargreave's process for making salt cake is said to produce a practically iron-free product, but this process is not generally used in the United States. The same result is obtained by making salt cake in lead pans, which requires considerable skill, or by preparing Glauber's salt from crude salt cake. Sodium sulphate as salt cake is also used in making paper pulp by the sulphate process and in making sodium sulphide, and a small quantity is used by aniline manufacturers and in making ultramarine.

It is claimed that sodium sulphate can be used instead of sodium carbonate in the soda wood pulp industry. In this process of making pulp the waste liquors containing sodium carbonate and carbonaceous matter are evaporated and the residue is finally calcined to recover sodium carbonate. If sodium sulphate is added to the waste liquors it is converted by calcination into sodium sulphide, which is said to have the same action on pulp as caustic soda. But if the proper quantity of limestone is added before calcining it appears that sodium carbonate would be the principal product obtained by extraction. This could then be causticized as usual.

Various patents have been granted for making sodium sulphate from sodium chloride with the simultaneous production of other compounds. Thus, H. B. Kipper in United States patent 1255020, issued January 29, 1918, uses a mixture of ferric oxide and sodium chloride in the presence of sulphur dioxide and oxygen, forming sodium sulphate and chlorine. L. P. Bassett uses clay, gypsum, and salt to form sodium sulphate and cement.

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Manufacturers.—The following firms produced sodium sulphate as salt cake in 1918:

American Steel & Wire Co., 502 Western Reserve Building, Cleveland, Ohio.
Ault & Wiborg Co., Cincinnati, Ohio.
Butterworth-Judson Corporation, 61 Broadway, New York, N. Y.
Consolidated Chemical Co., McKittrick, Calif.
Contact Process Co., 351 Abbott Road, Buffalo, N. Y.
E. I. du Pont de Nemours & Co., Wilmington, Del.
General Chemical Co., New York, N. Y.
Grasselli Chemical Co., Cleveland, Ohio.
Kalbfleisch Corporation, 31 Union Square west, New York, N. Y.
Charles Lennig & Co., Philadelphia, Pa.
Merrimac Chemical Co., 148 State Street, Boston, Mass.
Monsanto Chemical Works, St. Louis, Mo.
Mutual Chemical Co. of America, New York, N. Y.
National Zinc Co., Kansas City, Kans.
Naugatuck Chemical Co., Elm Street, Naugatuck, Conn.
Pennsylvania Salt Manufacturing Co., Philadelphia, Pa.
Powers-Weightman-Rosengarten Co., Philadelphia, Pa.
Stauffer Chemical Co., 624 California Street, San Francisco, Calif.
Western Chemical Manufacturing Co., West Bryant Avenue and South Pecos Street, Denver, Colo.

GLAUBER'S SALT.

The hydrated salt obtained by recrystallization below 32.4° C. ($Na_2SO_4.10H_2O$), Glauber's salt, is in demand where purity is an essential. It is used in dyeing, in tanning, in the textile industry as a mordant assistant, and in medicine. It is, however, an expensive form in which to transport sodium sulphate. Much Glauber's salt is made from impure salt cake, which after heating to remove the excess water is sold as "glassmaker's salt cake."

The Glauber's salt marketed in 1918 amounted to 50,715 short tons, valued at $1,041,070.

The following list gives the manufacturers of Glauber's salt in 1918:

Atlantic Carbonic Co., 258 Third Street, Chelsea, Mass.
Burns Manufacturing Co., 15 Beaver Street, New York, N. Y.
Central Chemical Co., foot of Chapel Street, Newark, N. J.
Columbus Crystal Co., 15 Arch Street, Newark, N. J.
E. I. du Pont de Nemours & Co., Wilmington, Del.
Durex Chemical Corporation, 320 Fifth Avenue, New York, N. Y.
General Chemical Co., New York, N. Y.
Grasselli Chemical Co., Cleveland, Ohio.
Iowa Soda Products Co., Detroit, Mich.
Kalbfleisch Corporation, 31 Union Square west, New York, N. Y.
Kimberly-Clark Co., Neenah, Wis.
Charles Lennig & Co. (Inc.), Philadelphia, Pa.
Mechling Bros. Manufacturing Co., Camden, N. J.
Merrimac Chemical Co., 148 State Street, Boston, Mass.
National Zinc Co., Kansas City, Kans.
Pennsylvania Salt Manufacturing Co., Philadelphia, Pa.
Powers-Weightman-Rosengarten Co., Philadelphia, Pa.
E. R. Squibb & Sons, 60 Beekman Street, New York, N. Y.

NITER CAKE.

Niter cake, the residual product in the manufacture of nitric acid from sodium nitrate and sulphuric acid, differs from salt cake in containing acid sodium sulphate ($NaHSO_4$) in varying quantity. Manufacturers report either the percentage of bisulphate or the percentage of sulphuric acid in the product. Pure sodium bisulphate carries 40.8 per cent of sulphuric acid and commercial grades carry from 25 to 35 per cent of sulphuric acid, which corresponds to 61 to 86 per cent of sodium bisulphate.

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The quantity of niter cake made in the United States in 1918 was very large, owing to the demand for nitric acid for making explosives, and much of the niter cake was not marketed.

The marketed production amounted to 143,155 short tons, valued at $595,660.

This quantity of niter cake accounts for only about 72,000 tons of sodium nitrate, whereas the Department of Commerce reports the importation of 2,069,379 short tons of sodium nitrate from Chile in 1918. The difference in these figures may be partly accounted for by the consumption of niter cake in making hydrochloric acid and sodium sulphide, but in any case a very large quantity represents either niter cake not utilized or sodium nitrate that went into fertilizers or was stored for future use. Very few manufacturers of fertilizers making sulphuric acid have reported the production of niter cake, which, if made, is doubtless consumed in their own works.

Niter cake may be prepared in a friable form by adding sodium carbonate or any substance that evolves a gas to melted niter cake.

Niter cake is used as a substitute for sulphuric acid for many purposes, as in metal pickling, in absorbing ammonia, in making paper, sodium sulphate, and fertilizers. Experiments have shown that superphosphates containing 15 per cent of available P_2O_5 can be readily produced from Florida pebble phosphate by mixing the finely ground material with niter cake, the reaction taking place without applying heat. Too much sodium sulphate in fertilizers, however, is considered objectionable by some authorities.

The following firms manufactured niter cake in 1918:

Aetna Explosives Co., New York, N. Y.
American Steel Wire Co. of New Jersey, 502 Western Reserve Building, Cleveland, Ohio.
American Zinc & Chemical Co., Oliver Building, Pittsburgh, Pa.
Armour Fertilizer Works, Chicago, Ill.
Atlas Powder Co., Wilmington, Del.
Ault & Wiborg Co., Cincinnati, Ohio.
Butterworth-Judson Corporation, 61 Broadway, New York, N. Y.
Central Chemical Co., Newark, N. J.
Contact Process Co., 351 Abbott Road, Buffalo, N. Y.
Charles Cooper & Co. (Inc.), Newark, N. J.
Davison Chemical Co,, Baltimore, Md.
E. I. du Pont de Nemours & Co., Wilmington, Del
General Chemical Co., New York, N. Y.
Grasselli Chemical Co., Cleveland, Ohio.
Kalbfleisch Corporation, 31 Union Square west, New York, N. Y.
Charles Lennig & Co. (Inc.), Philadelphia, Pa.
Merrimac Chemical Co., 148 State Street, Boston, Mass.
Monsanto Chemical Works, St. Louis, Mo.
National Zinc Co., Kansas City, Kans.
Naugatuck Chemical Co., Naugatuck, Conn.
Pennsylvania Salt Manufacturing Co., Philadelphia, Pa.
Powers-Weightman-Rosengarten Co., Philadelphia, Pa.
Robinson Bros., Seneca and Montrose Avenues, Brooklyn, N. Y.
Semet-Solvay Co., Syracuse, N. Y.
Tennessee Copper Co., 61 Broadway, New York, N. Y.
Victor Chemical Works, Fisher Building, Chicago, Ill.
Virginia-Carolina Chemical Co., Richmond, Va.

NATURAL SODIUM SULPHATE.

Some of the analyses on pages 176–178 indicate that sodium sulphate is an abundant constitutent of surface salts in several localities, especially in Wyoming, Utah, and Nevada. Sodium sulphate is found in many soils in regions of deficient rainfall, being known as

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white alkali, in contrast to sodium carbonate, which is known as black alkali on account of its corrosive action on vegetation. The exact proportion of white alkali that may exist in a soil without being positively deleterious is a matter of disagreement among soil experts, but small quantities are certainly not fatal to many crops.

Hydrated sodium sulphate ($Na_2SO_4.10H_2O$) decreases markedly in solubility with falling temperature, so that it deposits from many lakes containing strong brine in cold weather. Gilbert[1] says that this salt is deposited from the Great Salt Lake in cold weather and thrown up in heaps on the shore. Experiments by the writer have shown that the separation begins at 1°C. In Sevier Lake, Utah, which is at times entirely dry, the salts have been alternately dissolved and redeposited, with the result, as noted by Gilbert, that the sodium sulphate is chiefly found near the center and sodium chloride near the margin of the lake. Some "lakes" in western Saskatchewan, Canada, are reported to contain very large quantities of nearly pure Glauber's salt, and this salt, which is known mineralogically as mirabilite, as well as the anhydrous salt, thenardite, has been reported in considerable abundance at several localities in the Western States.

Natural sodium sulphate has been utilized at various times in small quantity. It seems as if greater use could be made of it. When it occurs mixed with sodium carbonate the mixture may be regarded as having been carried nearly through the Leblanc process, so that instead of attempting to separate the two salts it might be possible to transform the sulphate into carbonate by calcination with limestone and coal producing soda ash, a large proportion of soda ash being already present in the natural salts. Moreover, the natural mixture might be used directly in making glass.

John D. Gill and associates, Cheyenne, Wyo., and the Consolidated Chemical Co., McKittrick, Calif., reported the production of natural sodium sulphate in 1918. Natural sodium sulphate has also been produced commercially at Sweetwater Valley, Wyo., and the salt has been refined by C. W. Beers, 1188 West Thirtieth Street, Los Angeles, Calif.

In 1885 Weeks[2] described natural sodium carbonate and sulphate near Laramie, Wyo., and the manufacture of caustic soda from these materials.

The Southern Chemical Co., Mills Building, El Paso, Tex., conducted experimental work in 1918 on the production of anhydrous sodium sulphate from their deposit of the natural salt near Valmont, N. Mex. Commodity rates have been granted to shipments of this material.

SODIUM SULPHIDE.

Sodium sulphide (Na_2S), may be formed by heating salt cake with coal, but it is more economical to make it from niter cake, sodium chloride, and coal, with the incidental production of hydrochloric acid. After lixiviation the product is obtained as crystals ($Na_2S.9H_2O$), carrying about 32 per cent of sodium sulphide. A more concentrated salt may be prepared by evaporating until the temperature reaches about 160° C. and then allowing the liquor to cool. The product thus obtained carries about 62 per cent of sodium sulphide.

[1] Gilbert, G. K., U. S. Geol. Survey Mon. 1, p. 253, 1890.
[2] Weeks, J. D., Glass materials: U. S. Geol. Survey Mineral Resources, 1885, pp. 551–552, 1886.

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For preservation and transportation a more nearly anhydrous salt is desirable. The General Chemical Co. sells a product known as "chipped" sodium sulphide.

Sodium sulphide is used in dyeing, in cleaning fabrics, in making the sulphur dyes and other dyes, in tanning, for removing hair from skins, in sulphurizing oxidized lead and copper ores preparatory to flotation, and in precipitating silver from cyanide solutions. A dilute solution of it has also been used as a solvent for gold in the hydrometallurgy of gold ores, the gold being later precipitated by copper or an aluminum-zinc alloy, as described by F. Wartenweiler.[1]

The production of sodium sulphide in the United States in 1918 amounted to 43,490 short tons, valued at $2,293,304. This material includes both the 32 and 62 per cent grades, the larger part, however, being the 62 per cent grade. The quantity is slightly less than that reported in 1917, 49,494 short tons, which included more of the 32 per cent grade. The value is greater than that of any previous year for which figures are available.

The production of sodium sulphide given by the Bureau of the Census for 1914 was 20,263 tons, valued at $516,644, and 7,673 tons, valued at $206,450, for 1909.

In 1918 there was imported for consumption 112,821 pounds of sodium sulphide, valued at $4,673, according to the figures of the Department of Commerce, whereas the imports in 1917 were 288,292 pounds, valued at $5,104.

The following list gives the manufacturers of sodium sulphide in 1918:

Ault & Wiborg Co., Cincinnati, Ohio.
Contact Process Co., 351 Abbott Road, Buffalo, N. Y.
Charles Cooper & Co., Newark, N. J.
Durex Chemical Corporation, 320 Fifth Avenue, New York, N. Y.
General Chemical Co., New York, N. Y.
Grasselli Chemical Co., Cleveland, Ohio.
Charles Lennig & Co. (Inc.), Philadelphia, Pa.
Merrimac Chemical Co., 148 State Street, Boston, Mass.
Rollin Chemical Co., South Charleston, W. Va.

SODIUM TETRABORATE (BORAX).

COMPOSITION.

Sodium tetraborate ($Na_2B_4O_7.10H_2O$), commonly called borax and by some sodium biborate, is both a mineral and a manufactured product. Crude natural borax is known as tincal. It is found in San Bernardino County, Calif., associated with gypsum, anhydrite, thenardite, glauberite, hanksite, halite, and trona; also in several other counties in California; in saline lakes and playas in Nevada and Oregon; and in the hot springs of the Yellowstone Park. The present source of refined borax in the United States, however, is the mineral colemanite ($Ca_2B_6O_{11}.5H_2O$), from which borax is manufactured by treatment with sodium carbonate.

The formula of borax given above represents the hydrate formed at ordinary temperature. The crystals effloresce, however, when exposed to the air and lose in all $5H_2O$ below 100° C., the sixth molecule at 100°, the seventh and eighth at 130°, the ninth at 150°, and the tenth at 160° and above, the last molecule being held so tenaciously that 300° is desirable to insure complete desiccation, according to J. Hoff-

[1] Inst. Mining Met. Bull., vol. 166, 15 pp., 1918.

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man.[1] The very careful experiments of Smith and Van Haagen [2] show that even borax glass still retains about 0.2 per cent of moisture under ordinary conditions.

PRODUCTION AND PRICES.

The quantity of borax sold in the United States in 1918 was 26,673 short tons, valued at $3,909,565. This salt was produced by the Pacific Coast Borax Co., 100 William Street, New York, which produces both borax and boric acid, as do also Charles Pfizer & Co., 81 Maiden Lane, New York City; and the Thorkildsen-Mather Co., Forty-fifth and Elizabeth streets, Chicago, Ill.

According to quotations in the trade journals, the price of borax was steady throughout 1918, ranging from 6½ to 10 cents a pound, but most of the time holding close to 8 cents.

PATENTS.

In United States patent 1259717, issued to H. Blumenberg, March 19, 1919, it is proposed to treat calcareous boron ore with nitric acid to form boric acid and calcium nitrate. Patent 1259718 seeks the recovery of nitric acid from the calcium nitrate.

USES.

Borax on fusion dissolves the oxides of the metals, forming characteristically colored glasses that are useful in blowpipe tests. Fully a third of the borax consumed annually in this country, however, is used in the manufacture of enamels or porcelain-like coatings for such objects as bathtubs, kitchen sinks, and cooking utensils. Borax is also used as a flux in the melting and purification of the precious metals, in decomposing chromite, in making glass, as a preservative, and as a cleansing agent.

SOURCES OF DOMESTIC BORAX.

So far as known to the writer, domestic borax was derived entirely in 1918 from the mineral colemanite, which is produced from a few mines in southern and southeastern California, but the American Trona Corporation was reported as expecting to produce from 20 to 30 tons of refined borax daily in 1919 from the water of Searles Lake. The latest information is that production from this source is under way. The development represents an entirely new feature in the domestic borax industry.

According to reports received by the United States Geological Survey the production of crude boron ore in California in 1918 was 88,794 tons, valued at $2,263,230, as against 108,875 tons, valued at $3,609,632, in 1917.

A map showing the location of borax deposits in the western United States will be found in Mineral Resources for 1916, Part II, page 389.

Some new deposits of boron ores have been discovered at Muroc, Kern County, Calif. The Stauffer Chemical Co. continued prospecting on the north side of Frazer Mountain, in Ventura County, but without material results up to June, 1919.[3] No ore was mined by this company in 1918.

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[1] Chem. Industry, vol. 39, p. 411, 1916.

[2] Smith, E. F., and Van Haagen, W. K., The atomatic weights of boron and fluorine: Carnegie Inst. Washington Pub. 267, 1918.

[3] Yale, C. G. Personal communication.

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Most of the boron ore mined in California is concentrated before being shipped to the borax producers. At the Lang property of the Sterling Borax Co. this treatment includes heating, which drives off most of the water, disintegrates the colemanite, and causes the admixed clay to gather into lumps that are easily separated. The concentrated ore runs from 30 to 45 per cent of boric oxide. In 1917 the Pacific Coast Borax Co. put in Wilfley concentrators to work over old tailings and reported a good recovery. The concentrated ore was valued at $0.97 to $1 a unit of B_2O_3.

IMPORTS.

Borax is no longer imported into the United States and practically no boron ores, but 259,096 pounds of boric acid, valued at $26,436, was imported in 1918. This is the smallest quantity, with the exception of 232,545 pounds in 1912, for many years, the value, however, being larger than that for any year as far back as 1906, when 986,021 pounds, valued at $33,200, was imported.

FOREIGN BORATES.

An excellent bibliography of papers relating to borax and borates, by H. S. Gale, will be found in the chapter on borax in Mineral Resources for 1913. The descriptions given below are intended to refer chiefly to the deposits that are now being actively worked in various parts of the world.

Chile.—The borate deposits of Chile are near the salars or near the western Cordillera, at relatively high altitudes of the Andes in the Provinces of Tarapaca, Antofagasta, and Atacama. They have been described by several investigators [1] and are usually considered as having been derived originally from volcanic sources and later carried in solution to their present positions. One of the most important deposits is that of Lake Ascotan, near the station of Cevollar, in Antofagasta, first discovered in 1859 and at present operated by Borax Consolidated (Ltd.), London. The ore is sodium-calcium borate. Although periodic attempts have been made to convert the calcium borate in the various Chilean deposits into either borax or boric acid it is understood that at present the material is exported as calcium borate, which after drying or calcining carries more than 40 per cent B_2O_3. Import duties into the principal European countries favor the introduction of unrefined material as contrasted with half-refined or manufactured material.

Other South American countries.—Borates are found in the salars of northwestern Argentina, southwestern Bolivia, and southern Peru, just as in those of Chile, and are occasionally unaccompanied by the usual salts of the salars. The ore from these deposits has been carried to the various shipping points mostly on mule back.

Germany.—Several boron minerals are found in the Stassfurt deposits and have been worked for boric acid, but no statistics are available as to the production from this source.

Italy.—The fumaroles of Tuscany are well known as a source of boric acid and illustrate the association of boric acid with volcanism. They were described by R. Nasini in the report of the Sixth International Congress of Applied Chemistry, Rome, 1906. Italy has been an important exporter of boric acid for many years.

[1] See Clarke, F. W., The data of geochemistry: U. S. Geol. Survey Bull. 616, p. 249, 1916.

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Turkey.—The mineral pandermite ($2CaO.3B_2O_3.3H_2O$), which is found as a stratum underlying gypsum in Asiatic Turkey near the Sea of Marmora, has long been shipped to Europe as a source of borax and boric acid.

Russia.—On the peninsula of Kertch, near the Sea of Azov, Crimea, borax occurs among the erupted substances of the so-called mud volcanoes. It effloresces on the surface of the dried mud, more or less mixed with salt and soda, but so far as known has never been utilized commercially.

Tibet.—Crude borax, called tincal, is transported overland on sheep back from the high regions of the Himalayas to Calcutta.

SODIUM THIOSULPHATE.

Sodium thiosulphate, which is very generally known in the trade as sodium hyposulphite or "hypo," is made by treating sodium sulphite with sulphur, or from milk of lime, sulphur, and soda ash, or from waste materials containing sulphur, such as Leblanc tank waste.

The principal use of this salt is in the leather trade. It is also used in the textile industry for removing the last traces of chlorine from bleached fabrics, and in bleaching wool, straw, oils, ivory, and bones (as a source of sulphur dioxide), and in dyeing, in analytical chemistry, and in the manufacture of dyes, paper, and mordants. Its use in photography as a fixing agent depends on its solvent action on silver salts which have not been affected by light.

United States patent 1270150, issued June 18, 1918, to A. K. Gyzander, proposes to make sodium thiosulphate by treating sodium sulphite with hydrogen under pressure of 100 atmospheres for 24 hours.

The production of this salt in the United States in 1918 was 26,868 short tons, valued at $1,051,623.

Sodium thiosulphate was manufactured in 1918 by

General Chemical Co., New York, N. Y.
Grasselli Chemical Co., Cleveland, Ohio.
Charles Lennig & Co. (Inc.), Philadelphia, Pa.
Mechling Bros. Manufacturing Co., Camden, N. J.

MISCELLANEOUS SODIUM COMPOUNDS.

A scattered production of various sodium salts, chiefly organic chemicals used in analytical chemistry, photography, and medicine, was reported in 1918, which can not be given in detail without revealing figures of individual producers. The list includes sodium citrate, sodium phenolsulphonate, sodium salicylate, sodium oxalate, sodium arsenate, sodium arsenite, sodium bitartrate, sodium tartrate, sodium hypochlorite or chlorinated soda solution, sodium formate, sodium succinate, sodium permanganate, and sodium sulpho carbolate.

The total production of these salts reported amounts to 381 short tons, valued at $1,122,552.

The producers reporting include

Heyden Chemical Works, New York, N. Y.
Mallinckrodt Chemical Works, St. Louis, Mo.
Semet-Solvay Co., Syracuse, N. Y.
E. R. Squibb & Sons, New York N. Y.

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PHOSPHATE ROCK.[1]

By RALPH W. STONE.

PRODUCTION.

PHOSPHATE ROCK SOLD.

The phosphate rock marketed in the United States in 1918 was 2,490,760 long tons, valued at $8,214,463. As compared with the production in 1917, which amounted to 2,584,287 long tons, valued at $7,771,084, there was a decrease in quantity of 93,527 tons, or 3.6 per cent, and an increase in value of $443,379, or 5.7 per cent. In this report the value of domestic material means selling value f. o. b. mines.

Phosphate rock sold in the United States, 1909–1918.

Year.	Quantity (long tons).	Value.	Year.	Quantity (long tons).	Value.
1909	2,338,264	$10,796,456	1914	2,734,043	$9,608,041
1910	2,654,988	10,917,000	1915	1,835,667	5,413,449
1911	3,053,279	11,900,693	1916	1,982,385	5,896,993
1912	2,973,332	11,675,774	1917	2,584,287	7,771,084
1913	3,111,221	11,796,231	1918	2,490,760	8,214,463

PHOSPHATE ROCK MINED.

The quantity of phosphate rock mined in any year is not the same as that sold, for the quantity in stock at the mines at the end of each year is variable. The quantity mined in 1918 was 2,284,245 long tons, a decrease of 567,641 tons, or 19.9 per cent from the output of 1917. The decrease in production was general. In Florida the decrease was 443,247 tons, or 19 per cent, with 28 plants in operation, 9 less than in 1917; in South Carolina 11,868 tons, or 26 per cent, with 3 producing plants, as in 1917; in Tennessee 108,160 tons, or 23.8 per cent, with 21 plants in operation, 2 less than in 1917; and in the Western States 4,479 tons, or 27 per cent, with 3 producers instead of 4.

STOCKS.

Stocks on hand at the end of 1918 were about 1,127,000 tons, a decrease of about 260,000 tons, or 19 per cent, from the stocks at the close of 1917. The stocks on hand in Florida were reported to be about 1,046,000 tons and in Tennessee about 61,000 tons. This decrease in stocks was due to the fact that in Florida, South Carolina, Tennessee, and Kentucky more rock was sold than was mined.

[1] The statistical tables in this chapter, except those showing imports and exports, were prepared by Miss L. M. Jones, and the tables of imports and exports were compiled from the records of the Bureau of Foreign and Domestic Commerce by J. A. Dorsey, both of the United States Geological Survey.

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PRODUCTION BY STATES.

OUTPUT AND PRICE.

In 1918 there was a small increase in quantity of phosphate rock sold in Florida and South Carolina, but a larger decrease in quantity sold in Tennessee and the Western States, making a net decrease for the country. On the other hand, the average price per ton increased in all States, the percentages of increase being 9 in Florida, 7 in South Carolina, 24 in Tennessee, and 27 in the Western States. The increase in average price per ton in the whole country was from $3.01 in 1917 to $3.30 in 1918, or nearly 10 per cent.

Phosphate rock sold in the United States, 1917–18.

State.	1917			1918		
	Quantity (long tons).	Value.	Average price per ton.	Quantity (long tons).	Value.	Average price per ton.
Florida:						
Hard rock	18,608	$159,366	$8.56	62,052	$377,075	$6.08
Soft rock				8,331	147,103	17.66
Land pebble	2,003,991	5,305,127	2.65	1,996,847	5,565,928	2.79
	2,022,599	5,464,493	2.70	2,067,230	6,090,106	2.95
South Carolina:						
Land rock	33,485	138,482	4.14	37,040	164,650	4.45
Tennessee:						
Brown rock	[a] 447,203	[a] 1,920,533	4.29	[a] 374,535	[a] 1,917,546	5.12
Blue rock	65,904	205,820	3.12			
	[a] 513,107	[a] 2,126,353	4.14	[a] 374,535	[a] 1,917,546	5.12
Western States [b]	15,096	41,756	2.77	11,955	42,161	3.53
	2,584,287	7,771,084	3.01	2,490,760	8,214,463	3.30

[a] Includes several thousand tons of brown rock from Kentucky.
[b] Includes, 1917: Idaho, Utah, and Wyoming; 1918: Idaho and Utah.

FLORIDA.

In 1918 Florida, the leading State in the production of phosphate rock, marketed 2,067,230 long tons, valued at $6,090,106, or 83 per cent of all the phosphate rock sold in the United States. This was an increase of 44,631 tons, or 2.2 per cent, over the shipments of 1917, but the total nevertheless was nearly 500,000 tons less than that of 1913, the last year of normal production.

Hard-rock phosphate, which was the variety most exported before the war, decreased in output from nearly 500,000 tons in 1913 to less than 20,000 tons in 1917. It seems to have reached the limit of depressed output in 1917 for the quantity sold in 1918 was 62,000 tons, an increase which suggests perhaps a preparation on the part of the producers of hard-rock phosphate to begin exportation in large quantity as soon as opportunity offers.

Soft-rock phosphate is now produced by three companies in Florida and the figures can be shown separately for the first time. This could not be done formerly without revealing confidential informa-

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tion. The output in 1918 was somewhat greater than in 1917. The quantity of land pebble produced in 1918 was 7,144 tons less than in 1917, a very small quantity considering that the total output in each of these years was approximately 2,000,000 tons. There was a great decrease in the quantity of phosphate reported by the original producers as sold as ground rock, only 12,329 tons, in comparison with 27,690 tons in 1917.

The average price per ton of hard rock was $6.08, as compared with $6.10 in 1913. The average price per ton of soft rock increased from $12.40 in 1917 to $17.66 in 1918, but the latter figure may be too high, because freight rates have apparently been included in the selling prices reported. The average price of land pebble increased from $2.65 in 1917 to $2.79 in 1918.

Florida phosphate rock sold in 1913–1918.

Year.	Hard rock.		Soft rock.	
	Quantity (long tons).	Value.	Quantity (long tons).	Value.
1913	489,794	$2,987,274	.....	.....
1914	309,689	1,912,197	.....	.....
1915	50,130	265,738	.....	.....
1916	a 47,087	a 295,755	(a)	(a)
1917	a 18,608	a 159,366	(a)	(a)
1918	62,052	377,075	8,331	$147,103

Year.	Land pebble.		Total.	
	Quantity (long tons).	Value.	Quantity (long tons).	Value.
1913	b 2,055,482	b $6,575,810	2,545,276	$9,563,084
1914	b 1,829,202	b 5,442,547	2,138,891	7,354,744
1915	1,308,481	3,496,501	1,358,611	3,762,239
1916	1,468,758	3,874,410	1,515,845	4,170,165
1917	2,003,991	5,305,127	2,022,599	5,464,493
1918	1,996,847	5,565,928	2,067,230	6,090,106

a Several thousand tons of soft rock included with hard rock.
b Includes a small quantity of river pebble.

SOUTH CAROLINA.

The phosphate rock mined in South Carolina was land rock only and although the quantity mined was 11,868 tons, or 26 per cent, less than in 1917, the quantity sold was an increase of 3,555 tons, or 11 per cent. Stocks on hand at the close of the year, however, decreased from 20,918 in 1917 to 17,551 in 1918. The average price per ton increased from $4.14 to $4.45.

South Carolina phosphate rock sold in 1913–1918.

Year.	Quantity (long tons).	Value.	Year.	Quantity (long tons).	Value.
1913	109,333	$440,588	1916	53,047	$211,125
1914	106,919	415,039	1917	33,485	138,482
1915	83,460	310,850	1918	37,040	164,650

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TENNESSEE AND KENTUCKY.

The quantity of phosphate rock sold in Tennessee and Kentucky in 1918 was 374,535 tons, valued at $1,917,546, a decrease of nearly 27 per cent in quantity and a slight decrease in value from 1917. Nearly all this rock was mined in Tennessee, and all the decrease must ascribed to that State, for the production in Kentucky, which can not be shown separately because there was only one operator, was considerably greater in both quantity and value than in 1917. About 33,000 tons of Tennessee phosphate was reported by producers as sold as ground rock, a considerable decrease from 48,000 tons so reported in 1917. The average price per ton of Tennessee-Kentucky rock increased from $4.14 in 1917 to $5.12. In 1918 the average price per ton of brown rock was $5.26 and of blue rock $4.15, as compared with $4.29 for brown rock and $3.12 for blue rock in 1917. By far the larger quantity of phosphate mined in Tennessee was brown rock, of which more than 300,000 tons were sold. The exact figures can not be given without revealing confidential information concerning the production of Tennessee blue rock and the single producer in Kentucky.

Tennessee phosphate rock sold in 1913–1918.

Year.	Brown rock.		Blue rock.		Total.	
	Quantity (long tons).	Value.	Quantity (long tons.)	Value.	Quantity (long tons).	Value.
1913	[a] 451,559	[a] $1,774,392	(a)	(a)	451,559	$1,774,392
1914	[a] 483,203	[a] 1,822,770	(a)	(a)	483,203	1,822,770
1915	[b] 389,759	[b] 1,327,747	(a)	(a)	[b] 389,759	[b] 1,327,747
1916	[c] 364,108	[c] 1,357,888	47,682	$152,465	[c] 411,790	[c] 1,510,353
1917	[c] 447,203	[c] 1,920,533	65,904	205,820	[c] 513,107	[c] 2,126,353
1918	[a] [c] 374,535	[a] [c] 1,917,546	(a)	(a)	[c] 374,535	[c] 1,917,546

[a] Blue rock is included with brown rock.
[b] Includes some blue and white rock and a very small quantity of rock from Arkansas.
[c] Includes a small quantity of brown rock from Kentucky.

WESTERN STATES.

The phosphate rock industry in the Western States showed a decrease of 21 per cent in 1918, the shipments falling from 15,096 tons to 11,955 tons. There was an increase in total value however, from $41,756, or an average of $2.77 per ton, to $42,161, or $3.53 per ton, making the total value of the product greater than in any previous year. There were 3 producers in 1918 instead of 4, operations at Cokeville, Wyo., having been discontinued.

Western States phosphate rock sold in 1913–1918.

Year.	Quantity (long tons).	Value.	Year.	Quantity (long tons).	Value.
1913	5,053	$18,167	1916	1,703	$5,350
1914	5,030	15,488	1917	15,096	41,756
1915	3,837	12,613	1918	11,955	42,161

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WORLD'S PRODUCTION.

World's production of phosphate rock, 1910–1918, in metric tons.

Country.	1910	1911	1912	1913	1914	1915	1916	1917	1918
Algeria	319,069	332,897	388,515	377,934	[a] 355,140	[a] 225,891	[a] 389,211	202,539	234,825
Angaur Island	45,000	41,000	50,000	90,000	[a]60,000	30,000	30,000	.....	.....
Belgium	202,880	196,780	203,110	219,420	[a]10,988	.....	.....	.....	.....
Canada [b]	1,341	563	149	349	866	197	184	135	.....
Christmas Island	250,000	250,000	300,000	152,405	95,234	24,119	.....	.....	.....
Dutch West Indies:									
Aruba	27,838	88,430	17,215	38,150	86,572	51,000	14,700	3,639	.....
Curaçao	3,570	2,000	.....	1,850	11,219	32,915			
Egypt	2,397	12,013	70,918	104,450	71,945	82,998	125,008	115,732	31,147
France	333,506	312,204	330,000	298,859	270,000	.....	24,700	.....	.....
French Guiana	6,816	.....	.....	5,000	.....	.....	.....	.....	.....
Japan, including Rasa Island	1,042	2,271	7,849	25,013	38,264	57,723	114,389	.....	.....
Makatea Island	39	11,192	38,489	82,056	72,925	71,724	39,285	114,780	.....
New Caledonia, Huon Island	2,558	2,053	3,880	2,100	3,500	8,400	.....	.....	.....
New South Wales	.....	.....	.....	2,032	.....	.....	.....	.....	.....
New Zealand	.....	.....	.....	11,176	.....	.....	.....	5,557	.....
Norway	903	.....	.....	757	750	.....	.....	.....	.....
Ocean and Pleasant Islands	310,625	250,000	298,687	250,000	.....	.....	70,000	.....	.....
Russia	15,293	10,200	25,000	25,000	15,000	.....	.....	.....	.....
South Australia	5,283	5,893	6,197	6,045	6,197	4,688	5,093	5,183	.....
Spain	2,840	3,520	3,292	3,548	8,312	9,080	14,111	28,148	.....
Tunis	1,286,262	1,446,633	2,057,498	2,284,678	1,427,161	1,389,074	1,695,295	999,326	818,962
United States	2,697,468	3,102,131	3,020,905	3,161,000	2,777,788	1,865,038	2,014,103	2,625,636	2,530,612
	5,514,730	6,069,780	6,821,654	7,141,822	5,311,,861	3,852,847	4,536,079	4,100,675	.....

[a] Exports. [b] Apatite.

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IMPORTS OF FERTILIZER MATERIALS.

The fertilizer materials imported into the United States in 1918 comprised many compounds containing phosphorus, nitrogen, and potash. Those containing phosphorus include bone ash, guano, basic slag, and phosphate rock. The potash fertilizers include various potash salts, kainite, manure salts, and double manure salts. The nitrogen compounds are chiefly calcium cyanamid, nitrates, and ammonium salts.

The quantity of calcium cyanamid, or lime nitrogen, used in the United States has increased from 5,000 tons in 1911 to 47,268 tons in 1917, but fell off slightly in 1918 to 45,209 tons. It is a powder containing 20 to 22 per cent of nitrogen which is manufactured at Niagara Falls, Canada, and is used by more than 300 manufacturers of fertilizer in the United States.

Fertilizers imported and entered for consumption in the United States, 1914–1918.[a]

Fertilizer.	1914		1915		1916		1917		1918	
	Quantity (long tons).	Value.	Quantity (long tons).	Value.	Quantity (long tons).	Value.	Quantity (long tons).	Value.	Quantity (long tons).	Value.
Apatite	20	$300	.....	.....	.....	.....	.....	.....	1	$30
Bone dust or animal carbon, and bone ash, fit only for fertilizing	36,000	892,529	21,538	$543,243	18,117	$485,737	10,521	$308,497	5,098	153,349
Calcium cyanamid, or lime nitrogen	21,793	1,119,785	30,043	1,322,195	40,516	1,755,644	47,268	2,472,936	45,209	2,208,326
Guano	25,335	761,562	9,874	220,768	12,992	378,036	7,067	160,923	8,206	280,544
Kainite	313,898	1,551,115	6,674	95,440	36	1,173	.....	.....	.....	.....
Manure salts, including double manure salts	168,969	1,846,475	13,753	200,584	1,108	21,273	225	9,047	.....	.....
Phosphates, crude	15,079	136,526	5,359	50,606	4,612	36,389	92	1,169	.....	.....
Slag, basic, ground or unground	9,199	105,272	76	1,343	71	759	2	54	93	381
All other substances used only for manure	171,603	3,507,875	72,848	1,535,860	58,993	1,425,636	85,859	1,961,607	48,039	1,810,158
	761,896	9,921,439	160,165	3,970,039	136,445	4,104,647	151,034	4,914,233	106,646	4,452,788

[a] The statistics in this table are compiled from the records of the Bureau of Foreign and Domestic Commerce, Department of Commerce.

The preceding table, compiled from records of the Bureau of Foreign and Domestic Commerce, does not include all the material imported into the United States which goes into the fertilizers manufactured and sold in this country. To the materials listed in the table should be added potash salts, and a considerable quantity of sodium nitrate. The production of potash salts in the United States is described in another chapter in Mineral Resources.

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Imported materials used in part in the fertilizer industry in the United States, 1916–1918.[a]

	1916		1917		1918	
	Quantity (long tons).	Value.	Quantity (long tons).	Value.	Quantity (long tons).	Value.
Fertilizers	136,445	$4,104,647	151,034	$4,914,233	106,640	$4,452,788
Potassium chloride	1,160	348,961	610	158,410	379	102,109
Potassium sulphate	1,512	81,684	205	21,702	90	15,329
Sodium nitrate	1,219,609	38,131,364	[b] 1,543,200	60,727,100	1,847,660	90,216,935
	1,358,726	42,666,656	1,695,049	65,821,445	1,954,775	94,787,161

[a] The statistics in this table are compiled from the records of the Bureau of Foreign and Domestic Commerce, Department of Commerce.
[b] Revision of figures published for 1917.

There is a small trade in foreign fertilizer materials, which after being imported into this country are shipped elsewhere. The following table compares the export of these foreign fertilizers in 1915–1918:

Imported fertilizers shipped, 1916–1918.[a]

Kind.	1916		1917		1918	
	Quantity (long tons).	Value.	Quantity (long tons).	Value.	Quantity (long tons).	Value.
Ammonia sulphate	452	$41,755	219	$23,505	.....	.....
Bone dust and bone ash	.....	.....	113	1,004	.....	.....
Guano	68	5,864	.....	.....	.....	.....
Kainite	.....	3	.....	.....	.....	.....
Muriate of potash	.....	.....	29	10,465	.....	.....
Sulphate of potash	212	66,238	31	10,500	.....	.....
All other substances used only as fertilizers	.....	33,103	.....	21,441	.....	$24 288
	732	146,963	392	67,005	.....	24,288

[a] The statistics in this table are compiled from the records of the Bureau of Foreign and Domestic Commerce, Department of Commerce.

EXPORTS.

Since 1913, when more than 1,300,000 tons of phosphate rock was exported, the quantity leaving the United States has steadily decreased until in 1918 it was only 143,455 tons, a little more than one-tenth of the exports in 1913. The following table, compiled from reports of the Bureau of Foreign and Domestic Commerce, shows exports of phosphate rock in the last three years:

Phosphate rock exported from the United States, 1916–1918.[a]

Kind.	1916		1917		1918	
	Quantity (long tons).	Value.	Quantity (long tons).	Value.	Quantity (long tons).	Value.
Phosphate rock, ground or unground, not acidulated:						
High-grade rock	28,631	$286,948	12,403	$113,392	57,771	$445,419
Land pebble	214,358	863,078	138,010	548,203	64,559	303,758
All other	689	6,365	15,945	173,450	21,125	163,308
	243,678	1,156,391	166,358	835,045	143,455	912,485

[a] The statistics in this table are compiled from the records of the Bureau of Foreign and Domestic Commerce, Department of Commerce.

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The destination of these exports is shown in the following table, which brings out the facts that in 1916–1918 most of the high-grade rock exported went to Sweden and Norway, much of the land pebble to England, France, and Spain, and that Cuba and Canada were notable consumers of phosphate rock from this country.

Phosphate rock, ground or unground, not acidulated, exported from the United States, 1916–1918.

High-grade rock.

	1916		1917		1918	
	Quantity (long tons).	Value.	Quantity (long tons).	Value.	Quantity (long tons).	Value.
Canada	336	$3,729	111	$1,375	379	$5,823
Cuba			45	615	53	860
England					1,850	9,250
Mexico			10	108		
Norway			8,641	75,336	21,133	145,827
Spain	3,012	30,120				
Sweden	25,283	253,099	3,596	35,958	34,356	283,659
	28,631	286,948	12,403	113,392	57,771	445,419

Land pebble.

Belgium			4,769	$16,930		
Canada	2,761	$10,407	5,153	20,036	5,445	$20,991
Cuba	4,089	15,620	9,876	31,388	12,063	32,134
England	23,525	80,543	32,140	127,215	19,804	100,936
France	22,073	60,125	8,208	23,124	9,602	48,010
Ireland	25,023	94,568	7,500	25,500		
Italy	6,069	16,387			1,440	4,320
Netherlands	27,748	123,046	4,450	20,025		
Scotland	9,699	37,050	5,100	18,337		
Spain	62,179	273,789	60,814	265,648	11,848	73,312
Sweden	31,192	151,543			4,357	24,055
	214,358	863,078	138,010	549,203	64,559	303,758

All other phosphate rock.

Bermuda			298	$2,905		
British Honduras			1	9		
British Oceania [a]			500	6,000		
Canada	676	$6,280	5,408	61,205	8,419	$78,888
Cuba			7,555	82,484	4,388	32,327
Dutch East Indies	13	85				
England					2,525	13,080
Mexico			1	120		
Netherlands			2,182	20,727		
Norway					3,975	23,853
Sweden					1,818	15,150
	689	6,365	15,945	173,450	21,125	163,308

[a] Not including Australia and New Zealand. Reported by Bureau of Foreign and Domestic Commerce as "Other British Oceania."

The following table shows the quantity of phosphate rock produced in and exported from the United States during the last six years:

Phosphate rock marketed in and exported from the United States, 1913–1918.

Year.	Quantity marketed (long tons).	Exports (long tons).	Proportion of exports to domestic production (per cent).
1913	3,111,221	1,366,508	44
1914	2,734,043	964,114	35
1915	1,835,667	263,421	14
1916	1,982,385	243,678	12
1917	2,584,287	166,358	6
1918	2,490,760	143,455	6

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DISTRIBUTION AND CHARACTER OF DEPOSITS.

UNITED STATES.

FLORIDA.

Florida phosphate deposits are the most extensively developed in the United States. Four classes are mined—hard-rock, land-pebble, river-pebble, and soft-rock phosphate.

Hard-rock phosphate.—The hard-rock phosphate occurs as boulders and pebbles in a soft matrix of phosphatic sands and clays and other material, the whole resting on a limestone of lower Oligocene Age. The boulder deposits occur in the form of pockets of irregular size, ranging from a few square yards to several acres in area. The boulders themselves vary in size from a few inches to several feet in diameter. The phosphatic content of this class of deposit ranges from less than 10 to more than 30 per cent of the mass, the marketable product being not more than 15 per cent of the total mined material. The rock itself runs as high as 85 per cent in tricalcium phosphate and is sold on a guaranty of 77 per cent tricalcium phosphate.

The workable deposits are very irregular. At some places they are at the surface, elsewhere they may lie so deep as to be economically unworkable; equally promising drill records may indicate in one case an extensive deposit and in another a single boulder or pocket. There is no rule to which these hard-rock deposits agree in regard to depth from surface, thickness, lateral extent, quantity, and quality.

Hard-rock phosphate occurs over a considerable area which extends with varying width for about 100 miles in the western part of central peninsular Florida. The area extends from the southern part of Columbia and Suwanee counties through the western part of Alachua and Marion counties, and the eastern part of Levy, Citrus, and Hernando counties into the northern part of Pasco County. There is also a limited area in Lafayette, Taylor, and Jefferson counties. It must be understood that this is the general area in which the deposits occur, the workable deposits themselves being very much less than the area outlined.

There were four shippers of hard-rock phosphate in Florida in 1918 who had a total production of about 62,000 tons, or about one-eighth of the normal production prior to the European war. A large number of hard-rock mines were idle, much of the rock shipped being drawn from stocks on hand.

In mining hard-rock phosphate the overburden is usually removed by horsepower scrapers or by picks and shovels, although the removal in some places is by steam shovel and hydraulic. Mining is then by hand work with shovels or by steam shovel if the rock is above ground-water level; mining below ground-water level is by steam dredge.

The phosphate is loaded on small cars and raised from the pit by inclined cable railway to a washer where it passes through a grizzly. After passing a log washer it goes through cylindrical screens and is washed at the same time to remove sand and clay. The coarser material is sorted by hand on a revolving circular table. Hard rock is usually dried by stacking with wood under a shed and burning the wood; at some mines it has been dried by passing through a heated rotary metal cylinder. When cool it is ready for shipment.

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Land-pebble phosphate.—The pebble phosphate is composed of rounded or subangular pebbles up to the size of a walnut embedded in a matrix of sand, clay, and soft phosphate. The pebble deposits usually show more or less natural sorting, with alternating layers of coarse and fine material. The color of the pebbles ranges from light gray to blue or black. The land-pebble deposits are in beds of varying thickness, but they are much more regular than the hard rock, and for that reason cost less to mine. The workable deposits range from a few feet to 25 feet, and probably average 10 to 12 feet thick.

Land pebble is found resting on upper Oligocene limestone and marls, and overlain by sand. The thickness of the overburden ranges from a few feet to 40 feet and probably averages more than 15 feet.

The land-pebble deposits occur in an oval area 40 miles long and 30 miles wide, lying east of Tampa, in the eastern part of Hillsboro and the western part of Polk counties. The extent of the deposits is difficult to determine because the sands are not distinctive and the gravel is exposed at few places except in mines and pits. The principal centers of land-pebble phosphate mining are between Mulberry and Fort Meade in Polk County. Twelve producers in 1918 shipped 1,996,847 long tons of land-pebble phosphate, valued at $5,565,928.

Although the land-pebble deposit underlies a considerable area, it is mined at comparatively few places. Several factors determine the location of a mine. The thickness of the overburden must be considered, the quantity and quality of the phosphate economically available, and the distance from a railroad. Obviously the character as well as the thickness of the overlying sand affect the commercial utilization of a deposit. Soft sand can be removed by hydraulic but indurated sand may have to be blasted and then removed by steam shovel, which is so expensive that if the overburden is thick the phosphate can not be economically recovered unless it too is thick and several acres in extent.

Removal of the overburden from a deposit of land pebble is done by hydraulic or steam shovel. The pebble is then hydraulicked into a sump from which it is raised by centrifugal pumps and conveyed through pipes to the washer. The washers are much the same type as those used in cleaning hard-rock phosphate. From log washers the rock passes through revolving cylindrical screens, and is dried in inclined rotary kilns, from which it goes to the storage bins and is ready for shipment.

The phosphate content of the marketed product generally ranges from 60 to 75 per cent of tricalcium phosphate.

River-pebble phosphate.—Deposits of pebble-phosphate accumulated on river bars are found on several tributaries of St. Johns River and on Peace River. The pebbles have rounded outlines produced by mechanical abrasion and range from small granules to those 2 inches or more in diameter. The average diameter is less than an inch. River-pebble phosphate is usually stained dark by organic matter, but the discoloration is surficial. Fragments of bones and teeth of sharks and other animals are common in these deposits. In some places so many shells of marine organisms are mixed with the pebbles that mining is impracticable.

The pebbles are found in a matrix of sand and sandy clay of various colors. The deposits form parts of extensive accumulation of detritus in the valleys of some of the streams flowing through regions

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containing other types of phosphate. The quality of river-pebble phosphate is lower than that of hard rock or land-pebble phosphate, the composition ranging from 55 to 65 per cent tricalcium phosphate. This type of deposit has been mined principally in De Soto County along Peace River near Mulberry, Arcadia, Hull, and Fort Ogden. A few thousand tons were taken in 1911–1914, but there has been no production since 1914. Because of the character of the deposits and their very small extent it is not to be expected that there will ever be a large production of river-pebble phosphate.

Soft-rock phosphate.—Soft-rock phosphate forms a large portion of the matrix of hard-rock phosphate deposits and more or less of the matrix in land-pebble deposits. It is in fine powder or in soft masses that crumble to dust when dry but are very plastic when wet. It occurs also in small pockets in the limestone of the Vicksburg group, and in large bodies south of Greer, northwest of Ocala, and southwest of Richland. Large quantities of soft phosphate are mined with hard-rock phosphate, but in washing to remove the matrix the soft phosphate goes with the sand and clay to the waste heap. This constitutes a very considerable annual loss of phosphoric acid. In 1918 more than 8,000 tons of soft phosphate were mined and sold from Hernando, Levy, and Marion counties.

Further information on phosphate in Florida can be found in annual reports in Mineral Resources of the United States, in United States Geological Survey Bulletin 604 (Phosphate deposits of Florida) and in the fifth and seventh annual reports of the Florida State Geological Survey.

SOUTH CAROLINA.

The phosphate deposits of South Carolina are confined to a seaboard zone, most of it less than 30 miles wide, which extends from Beaufort on the south to 20 miles north of Charleston. Charleston is the center of the phosphate and fertilizer industry. The phosphate occurs in two forms, as land rock and as river rock. The land rock occurs in a more or less irregular bed which represents the undisturbed Edisto marl. It has a maximum thickness of 30 inches, but averages probably between 8 and 13 inches, and is in many places absent. It generally consists of an uneven or jagged mass of honeycombed rock. In places the cavities which are probably due to solution are as much as 4 inches in diameter. Much of the material is light yellowish brown and is soft and chalky.

The river rock probably consists in part of the original phosphatized Edisto marl and in part of fragments derived from the land deposits and concentrated on the river bottom, the whole deposit having been been worked over more or less by river action. It occurs generally in loose rounded fragments accumulated on the river bottoms. As would be expected in a river deposit, this reworked material is very irregular in distribution.

A tract of land rock to be mined is first thoroughly prospected. The overburden along a strip 20 feet wide is then removed by steam shovel and the phosphate taken up either by pick and shovel or by clamshell excavator. It is loaded on flat cars and sent to the washer. Hand mining can be done only where the overburden in less than 8 feet, and as the more accessible deposits have been exhausted this method is no longer used. Steam pumps or levees are necessary to keep water out of the excavations while mining is being carried on.

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River rock has not been reported as produced since 1910. In most of the more recent mining of river rock the clamshell dredge was used; one bucket dredge was also employed. The limit of depth of this work was about 50 feet of water.

The phosphate delivered from the dredge is mixed with sand and clay and must be washed and dried before it is ready to ship. Probably less than half of the material delivered from the flat cars to the hopper of the bucket elevator is phosphate. The conveyor dumps the rock into a crusher where it is broken and partly washed. The fragments are then delivered to the lower end of a metal cylindrical washer through which the material is carried up against a stream of water by a series of spiral plates. The washed rock is conveyed to wet bins and subsequently dried by being piled on ricks of wood, the burning of which drives off the moisture. It is estimated that by the present method about 20 per cent of the phosphate in finely pulverized form is lost in washing and goes to the waste dump.

In 1918 three phosphate plants in South Carolina were operated. The commercial rock varies greatly in phosphate content, but at no place does it contain more than 64 per cent tricalcium phosphate in the washed unburned condition. It is probable that the general average for the South Carolina area approximates 58 per cent tricalcium phosphate. In much of the rock the phosphate content is as low as 55 or 53 per cent. Rock of this grade competes with difficulty with the higher grade rock from Florida and Tennessee.

The production of the South Carolina field has fallen off greatly within the last few years. No river rock has been mined since 1910. There is no prospect that the industry will increase considerably in the near future, although the phosphate in the area is far from exhausted. It is estimated that there are probably at least 5,000,000 tons of 60 per cent phosphate still in the ground and improved machinery may at some time in the future make these deposits workable. That can scarcely be, however, until the high-grade and cheaply-mined phosphate in Florida and Tennessee is nearly exhausted.

TENNESSEE.

The phosphate deposits in Tennessee, which are classed as brown, blue, and white rock, are in the middle part of the State. Low-grade phosphate rock occurs in Johnson County in extreme eastern Tennessee, but it is not mined. The brown rock comes from Maury, Giles, Hickman, Lewis, and Sumner counties, and the blue rock from Lewis and Maury counties. White rock is found chiefly in Perry and Decatur counties, but none has been marketed since 1908.

Brown-rock phosphate occurs in plates of varying thickness and also as a porous material which disintegrates to phosphate sand. The two forms are commonly associated. It occurs in beds known as collar deposits and blanket deposits. Collar deposits are found where the horizontal phosphatic limestone bed outcrops on the slope of a steep hill, and the blanket deposits occur near the surface in broad, more nearly level areas. The deposits are of secondary origin and therefore are irregular in thickness.

Brown-rock phosphate has been dug in the Mount Pleasant region in Maury County, near Wales, Giles County, and on lower Swan Creek. The overlying clay is stripped by drag-line excavator,

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hydraulic jet, or horse scraper, and the phosphate rock which occurs in irregular fashion is dug by hand and hauled to the washers in dump carts or by dinky tram.

At the washer the rock is crushed, run through log washers, and dried either by open wood fire or by rotary kiln. The brown rock is sold under guaranty of 70 to 80 per cent tricalcium phosphate.

Blue-rock phosphate is of sedimentary origin and is mixed with clay, sand, and gravel. The strata range in thickness from a few inches to 2 or 3 feet, and occur along Leatherwood Creek in the western part of Maury County, south and east of Centerville and on both sides of Swan Creek in Hickman County, in the eastern part of Lewis County, and in Perry and Wayne counties. The rock contains 30 to 85 per cent tricalcium phosphate, but rock having the higher content does not occur in large quantities.

Blue-rock phosphate is a tough granular rock like limestone and is mined by the room and pillar method, as it occurs in flat-lying beds under good cover. The mined rock is hauled on tram cars to the crushing and drying plant where it is prepared for shipment. Washing is not necessary, and at some plants the rock is crushed and marketed without drying.

KENTUCKY.

Phosphate deposits in Kentucky are of the brown-rock type and occur in the form of loose-rock blanket deposits near the surface. The workable deposits vary from 1 to 6 feet in thickness and are very irregular. They originated from concentration in the weathering of phosphatic limestone. The cover of clay and soil varies from 2 to 10 feet. The only mine operated recently is near Wallace in Woodford County, which is the locus of the central Kentucky field. Phosphate rock occurs also near Lexington, Fayette County, and in Franklin, Scott, Clark, and Jessamine counties. Phosphate has been produced in recent years by one firm only and the output therefore can not be revealed.

ARKANSAS.

The phosphate deposits that have been developed in Arkansas are located in northwestern Independence County, along Lafferty Creek. The deposits extend over a considerable area in the north-central part of the State, and the phosphate horizon has been recognized in Stone, Izard, Searcy, Marion, Baxter, and Newton counties. This does not mean that phosphate rock will be found in all these counties of sufficiently high grade to work with profit wherever its horizon outcrops, but that an intelligent conception of its geologic position may enable it to be more readily found and prospected. In the area in which it is found only sedimentary rocks are exposed at the surface. The names and relative positions of these rocks with the phosphate-bearing formation are given below:

Carboniferous: Boone limestone (including St. Joe limestone member).
Devonian: Chattanooga shale (including Sylamore sandstone member).
Silurian: St. Clair limestone.
Ordovician:
Cason shale (phosphate horizon).
Fernvale limestone. } "Polk Bayou" limestone.
Kimmswick limestone. }
Izard limestone.

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The phosphatic beds themselves vary in character, ranging from those that are brown, sandy, and of low grade to those that on fresh surfaces are bluish gray, apparently without sand, and of uniform texture and color. Manganese ore is so commonly associated with the phosphate that it is a good guide in prospecting for it. In the areas where the development has taken place the phosphate rock occurs in two layers, only the upper one of which is worked, the lower being considered of too low grade for exploitation. The upper bed is a compact, homogeneous light-gray rock, with a specific gravity of about 3. The following section of the deposit on the hillslope between Lafferty Creek and White River, Independence County, shows the relations of the phosphate rock. As will be seen from the section its aggregate thickness is from 8½ to 10 feet.

Section containing phosphate beds.[1]

	Ft.	in.
St. Clair limestone.		
Brown to black shale	2	
Low-grade manganiferous iron ore	1	3
Green to dark-clay shale	1	2
High-grade phosphate	4½–6	
Manganiferous iron ore		2
Low-grade phosphate	4	
Polk Bayou limestone.		

Analyses made in the Survey laboratory show the best ore to run from 56 to more than 71 per cent in bone phosphate.

A small production was reported in 1915 and previous years, but none since 1915. Most of the phosphate removed from the Arkansas area is obtained in much the same manner as the blue rock in Tennessee. The rock is first stripped and mined around the hillslope until the overburden makes this method too expensive. Drifts are then run into the hill, and the rock is blasted out and hauled to the mouth of the drift for shipment. Some of the rock is dried by being piled upon ricks of wood, which are then burned. Fuel is abundant, and burning has the advantage of reducing freight charges.

UTAH.

The phosphate deposits of Utah occur at two horizons, in the upper Mississippian and in the Permian. The upper Mississippian deposits are in Rich and Cache counties. Beds near Logan, Cache County, are from 6 inches to 2½ feet thick and carry from 31 to 70 per cent of tricalcium phosphate. In Laketown Canyon, Rich County, there is a phosphate zone nearly 7 feet thick, and some of the material contains as much as 81.7 per cent of tricalcium phosphate. In the Oquirrh Range, 50 miles southwest of Salt Lake City, there is a deposit of phosphate rock that carries 67 to 75 per cent of tricalcium phosphate. The quantity available in these districts has not been determined.

In the Uinta region the beds of phosphate are 1 foot to 6 feet thick, and some contain 70 per cent of tricalcium phosphate. In the Ogden region some of the beds contain 39 to 62 per cent of tricalcium phosphate, and in Weber Canyon a single 13-foot bed has an average content of 46.1 per cent. In the Woodruff and Crawford mountains

[1] Purdue, A. H., Developed phosphate deposits of northeastern Arkansas: U. S. Geol. Survey Bull. 315, p. 469, 1907.

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the main bed is usually 5 to 6 feet thick and contains 70 per cent of tricalcium phosphate. This area contains about 96,750,000 long tons of high-grade phosphate rock. No estimate can yet be made of the quantity in the other regions.

The great body of the western phosphate occurs in Permian rocks, and rocks of this age are widely distributed through northeastern Utah. The Permian phosphate deposits are in Summit, Wasatch, Duchesne, and Uinta counties, along the northern and southern flanks of the Uinta Mountains, and to the north in Weber, Morgan, and Rich counties. They occur largely in public land which is at the disposal of the United States Government. On July 31, 1919, the area in Utah withdrawn as lands containing deposits of phosphate amounted to 302,465 acres.

The phosphate bed mined near Randolph, Utah,[1] is 4 to 6 feet thick, but is divided into two parts by a lean layer 2 to 7 inches thick, which separates about a foot of the high-grade ore at the bottom of the bed from the upper part. The dip of the bed is 50°. A main crosscut tunnel is driven to the bed and a drift turned along it both ways. Raises are put up from the drift and the ore stoped down. The upper bench is taken out first and the chutes and entries are cleared. Then the lean parting is mined out and put on the waste dump. When the entries have been cleaned again the lower bench is mined. The drift and stope is advanced again on the upper part of the bed, and the operation repeated. The rock is drilled by hand, blasted, and falls down the stopes into chutes at the bottom of the raises. It is trammed out of the mine in small cars running on a light track.

IDAHO.

The known phosphate lands of Idaho lie in the southeastern part of the State, in Bear Lake, Bannock, Bingham, Bonneville, and Fremont counties. The Government has reserved 1,015,717 acres in Idaho as workable phosphate land, to which must be added 4,080 acres of officially classified phosphate land in the Fort Hall Indian Reservation. Idaho appears to contain the largest body of high-grade phosphate rock in the western field. In the Georgetown Canyon region there are three commercially workable beds, from 3 to 6 feet thick, that carry 72.9 to 82.3 per cent of tricalcium phosphate. The main bed throughout the Idaho district averages 5 or 6 feet in thickness and carries about 70 per cent of tricalcium phosphate. Estimates based on detailed studies indicate that the areas examined probably contain 5,200,000,000 long tons of tricalcium phosphate. These estimates include chiefly the main bed, which contains high-grade rock carrying 65 per cent or more of tricalcium phosphate; they do not include the thinner beds of high-grade rock nor the great body of low-grade material. Large areas of phosphate land have not yet been examined. Rock phosphate is mined and shipped from Montpelier and Paris, Bear Lake County.

The formation in which the phosphate occurs has been upturned and folded in the mountain-making processes, and the phosphate bed almost everywhere dips at a steep angle. The first mining of phosphate rock near Montpelier, Idaho, where the bed dips steeply with

[1] Stone, R. W., Phosphate rock industry of the United States: Rock Products, Oct. 8, 1918.

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the slope of the hill, was done by blasting from the ledge and rolling the rock down the incline to a stock pile. It was loaded into wagons and hauled to the railroad for shipment to the Pacific coast, where it was used for making superphosphate. This simple method of mining, however, is not applicable for long. With further development and increased production from a steeply dipping bed underground mining is employed.

The phosphate bed at the Waterloo mine near Montpelier, Idaho, is 5 feet thick and dips about 30°. Extraction of the rock was begun by an open cut, and quarrying covered an area about 200 feet square. Then tunnels were driven below the quarry to cut the bed well below the surface. According to a personal letter from W. F. Kett, of San Francisco Chemical Co., the development consists of crosscut tunnels to the deposit, then drifts along its course. Raises are run from the drifts 100 to 150 feet apart. Small pillars are left to protect the raises, and the ground between them is stoped. The raises are equipped with steel-bottomed chutes and the ore goes by gravity from the face of the stope down the chutes to mine cars in the drifts. The stopes are drawn clean, propped with heavy timbers, and left to cave. The pillars along the raises are robbed last. The rock is not very hard, and drilling is done with geared coal augers worked by hand. This method removes practically all the phosphate rock, which is carried from working face to stock bins by gravity.

Underground mining is employed at Paris, Idaho, to extract the phosphate rock which occurs in a steeply dipping bed striking north. Where the phosphate crosses the deep valley of Paris Creek a crosscut tunnel has been driven. According to a letter from Lewis A. Jeffs, president of the Western Phosphate Mining & Manufacturing Co., the crosscut reaches the bed at about 90 feet from the portal, with approximately 50 feet of stoping ground overhead at this point. A drift follows the bed for approximately 600 feet in a southerly direction, and in August, 1918, was advancing about 5 feet a day. The drift gains about 25 feet of backs or stoping ground for every 100 feet run along the bed. Raises and chutes are put in along the drift and the ore is stoped in the usual manner.

WYOMING.

The phosphate lands of Wyoming are in their western part contiguous to those of Idaho, from which they extend eastward through several mountain ranges in Uinta, Lincoln, and Fremont counties as far as the Owl Creek Mountains. The Government has reserved in Wyoming as phosphate land 998,592 acres, and has officially classified as phosphate land 20,576 acres in the Wind River Indian Reservation, a total of 1,182,816 acres of phosphate land in this State.

The richest deposit reported in northwestern Wyoming is in the canyon of Snake River, 3 miles below the mouth of Fall River. Here, besides the main bed, 9 feet thick, a random sample from which yielded 68.5 per cent of tricalcium phosphate, there are several beds from 2 to 12 feet thick, carrying from 20 to 60 per cent of tricalcium phosphate. In southwestern Wyoming, in the Sublette Ridge, Beckwith Hills, and Cokeville areas, the phosphate is comparable in quality and thickness with the Idaho rock, though the thickness of

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the high-grade bed, containing 70 per cent or more of tricalcium phosphate, is less uniform, apparently ranging from about 3 to 5 feet.

In the Wind River and Owl Creek mountains there are two phosphate beds, one of which is persistent throughout both ranges, and the other—the lower one—is limited to the southeastern part of the Wind River Range. On the northeastern slope of the Wind River Mountains, near Lander, along a front of 30 miles the upper bed is 3 to 5 feet thick and contains 40 per cent or more of tricalcium phosphate; elsewhere it is of only slight prospective value. In the same locality the lower bed across several townships is 2 to 4 feet thick and the content of tricalcium phosphate is 45 per cent or more.

The quantity of phosphate rock in the Wyoming fields is very great, though much of it is of medium or low grade. The Sublette Ridge, Beckwith Hills, and Cokeville areas are estimated to contain 37,200,000 tons of high-grade phosphate rock. It is not yet practicable to make estimates of the other fields. Rock has been shipped from Cokeville and Sage, Lincoln County.

At Cokeville, Wyo., tunnels have been driven at different levels on the strike of the bed which dips at a high angle. Overhead stopes have been opened through upraises from the drifts. The stopes are timbered and the ore settles between the timbers and is drawn through chutes into mine cars and dumped into the lower stopes. From the stopes above the lowest tunnel, the rock is dropped into cars and trammed out to bunkers from which wagons are loaded for hauling to the railroad. The rock is hard and air drills are used.

MONTANA.

Phosphate deposits occur at several places in Beaverhead, Granite, Powell, and Silver Bow counties, Mont. Phosphate was first discovered in Montana at Melrose in 1910 by a Government geologist, but the field in that vicinity has not been described in detail. The phosphate areas most fully known are at Elliston, Garrison, and Philipsburg.

In the Elliston area the main phosphate bed is 3 to 6 feet thick and carries 61 to 72 per cent of tricalcium phosphate. The outcrop is about 12 miles long and the field contains about 86,000,000 tons of high-grade rock.

In the Garrison field the economically important part of the phosphate deposit lies east of Hoover Creek. The trace of the bed is about 18 miles long and is in the form of a fishhook. The bed is believed to average 4 feet in thickness and analyses show that it contains an average of at least 60 per cent of tricalcium phosphate. If 3,000 feet is assumed as the depth of profitable mining, the Garrison field contains at least 97,000,000 tons of available rock phosphate. This estimate does not include layers of lower-grade rock in the eastern part of the field, or the thin bed of rock phosphate or sandstone containing nodules of phosphate in the western part of the field.

In the Philipsburg field the phosphate bed is so poorly exposed that few details of its thickness and character have been obtained. The evidence at hand, however, indicates that where it has not been deteriorated by faults or similar deformation the deposit is com-

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parable in size and quality to that of the eastern part of the Garrison field.

Near Melrose a bed of phosphate 6 feet thick averages about 65 per cent of tricalcium phosphate. About 8 miles of outcrop is known, but excavations have not been made to determine the thickness of the bed throughout this distance. Sufficient data are not at hand to permit an estimate of the quantity. The outstanding withdrawals of phosphate land in Montana July 31, 1919, were 287,883 acres.

Phosphate rock mining in Montana has not yet begun, although some of the deposits are very favorably situated with relation to railroad.

FOREIGN PHOSPHATE DEPOSITS.

NORTH AMERICA.

Canada.—The principal phosphatic rock in Canada is apatite; it occurs in workable quantity in two main districts, one in the Province of Ontario, the other in the Province of Quebec. The district in Ontario is 100 miles long and 75 miles wide, extending from St. Lawrence River northward toward Ottawa River over Addington, Frontenac, Lanark, Leeds, and Renfrew counties; the district in Quebec occupies a belt 15 miles wide, extending northward from Ottawa for an unknown distance. These deposits, which have been worked mainly by quarrying, are now practically abandoned. Rock phosphate occurs in a thin bed near Banff, Alberta, but is not used.

SOUTH AMERICA.

Dutch West Indies.—In Aruba and Curaçao, islands off the coast of Venezuela, there are deposits of phosphate rock, which is mined in small quantity and shipped to Europe. It is reported that the output in 1914 was about 100,000 tons and averaged 85 to 90 per cent of calcium phosphate.

French Guiana.—Phosphate deposits occur on the island of Salut and on the Connetables, close to the coast of French Guiana. The rock is exported.

Peru.—In the region of Ocucajo in the department of Ica there is a deposit of nodular lime phosphate. It is not used because of a local preference for guano.

Chile.—A large and rich deposit of phosphate is reported to occur in the valley of Huasco River about 300 miles north of Valparaiso. It has not been developed.

EUROPE.

Belgium.—The phosphate-producing districts of Belgium are near Mons and Liege. The Mons deposit consists for the most part of low-grade phosphatic chalk containing less than 26 per cent of tricalcium phosphate. Near Liege phosphates occur as a layer half a meter thick of phosphatic nodules in a matrix of phosphatic sand and average 50 per cent of tricalcium phosphate. The higher-grade phosphate deposits are exhausted, but this material, of lower grade than is usually mined elsewhere, can be used economically for direct application to the soil because it occurs in centers of consumption. The production from 1910 to 1913 averaged more than

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200,000 tons annually, making Belgium the leading European producer of phosphate rock.

France.—The principal deposits in France are in the Somme and Oise basins. The higher-grade deposits, carrying 50 to 80 per cent of bone phosphate, are nearly exhausted, and the principal production is phosphatic chalk carrying 25 to 27 per cent of bone phosphate. The output, which averaged more than 300,000 tons a year before the war, fell to 24,700 tons in 1916. There are low-grade deposits also in Cambresis, Ardennes, Auxerre, Burgundy, and in the Pyrenees Mountains.

Russia.—Important deposits of phosphate rock in Russia can be divided into the northern, central, and southern groups. The northern deposits are in the governments of Viatka, Vladimir, Kostroma, Riazan, Simbirsk, and Iaroslav; the central group is in the governments of Voronej, Kalouga, Koursk, Orel, Saratov, Smolensk, Tambov, and Chernigov; and the southern group in Podolia and Bessarabia, near the Galician frontier. The deposits of the southern group were the only ones exploited before the war, and the output was about 25,000 tons a year. This was very small in comparison with the size of the deposits, which are estimated to contain more than 1,500,000,000 tons. Some of the rock is high grade, carrying as high as 75 per cent of tricalcium phosphate, but the normal grade is about 50 per cent.

Spain.—The only deposits worked extensively in Spain are apatite veins at Aldea Moret, in the Province of Caceres. After being idle many years these deposits were reopened and produced 14,000 tons in 1916 and 28,000 tons in 1917.

Great Britain.—Low-grade phosphate in the form of beds of nodules occurs in Cambridgeshire, Suffolk, and Bedfordshire, England, and in Montgomeryshire, Wales. The production was 258,000 tons in 1876 but gradually decreased to less than 1,000 tons in 1900, since when all production has practically ceased, because the cheaply mined portions of the deposits have been exhausted. The total output from England since 1874 has been 1,205,000 tons.

Norway.—Apatite veins occur along the coast of southern Norway from Langesand to Lillesand, in the province of Kristiansand, and also in the Snarum district. The total production from 1851 to 1912 was 141,515 tons. Production reached 15,338 tons in 1882 but declined rapidly after 1891 and in recent years has averaged less than 1,000 tons annually.

AFRICA.

Tunis.—The principal deposits of phosphate rock in Tunis are the Gafsa fields in the southern half of the country. The phosphate occurs in beds several feet thick and only those carrying more than 58 per cent of phosphate are exploited. The deposits are of Eocene age, can be traced for several hundred miles, and constitute a reserve of hundreds of millions of tons. Tunis now produces more phosphate than any other foreign country, its annual output being between 1,500,000 and 2,000,000 tons, most of which goes to southern Europe.

Algeria.—The deposits of phosphate rock in Algeria are continuations of the deposits in Tunis. The two important mining districts are near the towns of Setif and Tebessa, in eastern Algeria. The

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production is more than 300,000 tons a year, and the exported rock carries 58 to 68 per cent of lime phosphate.

Egypt.—Extensive deposits of phosphate occur in Egypt near the Red Sea in thin and irregular beds of the same geologic age (Eocene) as the deposits in Tunis and Algeria. The best deposits average 70 per cent of lime phosphate and the output in 1916 was 125,000 tons.

There are mines 20 miles from Port Safalga and concessions 12 miles inland from Kosseir and also at Sebaia on the east bank of the Nile between Keneh and Assouan. Beds of phosphate are found in other districts on both sides of the Nile Valley. Practically all the raw rock phosphate produced is shipped from Egypt, principally to Japan, and contains 65 per cent or more of tricalcium phosphate.

Tripoli.—Deposits of phosphate occur 80 to 120 kilometers from the city of Tripoli in beds more than 1 meter thick. These beds probably are a continuation of the phosphate deposits in southern Tunis.

Morocco.—Deposits of phosphate are reported at El Boroudj, 125 kilometers south-southwest from Casa Blanca on the west coast and 70 kilometers from the end of a railroad. These deposits are said to be comparable to those in the Gafsa field in Tunis.

Senegal.—It is reported that at Dielor in Senegal, about the latitude of Cape Verde, which is the westernmost point on the African coast, there is a phosphate bed which is known to have a thickness of 2 meters to a depth of 64 meters. The rock carries only 50 per cent of tricalcium phosphate; hence it is not workable under present conditions, especially in view of the abundant high-grade rock in Algeria and Tunis.

Natal.—Phosphates have been found in Natal near Weenen, Ladysmith, and Byrnetown. The rock is in the form of reefs and nodules. The percentage of tricalcium phosphate in the phosphatic shales is too low for use in making superphosphates. The phosphatic nodules are of higher grade but too limited to be of value.

ASIA.

Siberia.—In the government of Uralsk, which is in southwestern Siberia bordering on the north end of Caspian Sea, there is reported to be 600,000,000 tons of phosphate rock. It is stated that the greater part of this material carries 17 to 20 per cent of phosphoric acid, which is equivalent to 36 to 43 per cent of tricalcium phosphate. The government of Turgai, which borders Uralsk on the east, is reported to contain 67,000,000 tons of phosphate rock, most of which carries 18 to 19 per cent of phosphoric acid, or about 40 per cent of tricalcium phosphate. The highest-grade material reported carries 24 per cent of phosphoric acid, equivalent to about 52 per cent of tricalcium phosphate. All the phosphate, therefore, is low grade. No production is reported from either of these localities.

Palestine.—Low-grade phosphate rock in sedimentary deposits of considerable extent and high-grade vein deposits along a fault line are reported as occurring between Es-Salt and Amman on the east side of Jordan. The sedimentary deposits occur also on the west side of Jordan. The known reserves are about 3,500,000 tons. The sedimentary deposits average about 48 per cent and the vein

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deposits 77 per cent of tricalcium phosphate. As the vein material is suitable for export these deposits have been explored by a French company, but so far as learned there has been no output.

ISLANDS IN NORTH PACIFIC OCEAN.

Rasa Island.—The discovery of phosphate rock on Rasa Island, 500 miles east of Formosa, a number of years ago resulted in the formation of a Japanese company for the exploitation of the deposits. The rock is rich, carrying 75 per cent of phosphate of lime, and reserves are estimated at 2,800,000 tons. In 1915 Rasa Island yielded 50,000 tons.

Angaur Island.—A former German supply of phosphate is the deposit on Angaur Island, in the Pelew group, east of the southern end of the Philippines. Reserves on this island are estimated at 2,000,000 to 4,000,000 tons of phosphate rock, mostly high grade. Germany increased the output from 45,000 tons in 1910, to 90,000 tons in 1913. Japan has held this island since October, 1914, and is mining 30,000 tons or more of phosphate annually.

Other islands.—Deposits of phosphate consisting of replacements of dolomitic coral limestone by leachings from guano are reported on several other islands in Oceania, as Baker and Fanning islands in Polynesia, and Fais Island in the West Caroline Islands. It is probable that there are undiscovered commercial deposits on other islands.

ISLANDS IN INDIAN AND SOUTH PACIFIC OCEANS.

Australia.—North of Adelaide, South Australia, in the vicinity of Clinton, Kooringa, and Bright, there are pockety deposits of phosphate without regular stratification and of varying quality. Some is replacement of dolomitic limestone. An output of 4,000 to 6,000 tons is made annually. In the parish of Barrajin, County of Ashburnham, New South Wales, about 8 miles from Canowindra railway station, there is a small area in which phosphate occurs in irregular masses in residual clay resulting from weathering of limestone. The rock carries from 48 to 83 per cent of tricalcium phosphate.

New Zealand.—In the Otago district, at Millburn, near Clarendon, New Zealand, there are beds of phosphate 3 to 12 feet thick resting in pockets in limestone. There has been very little if any production.

New Caledonia.—On Huon Island, about 300 kilometers northwest of the north end of New Caledonia, there is a deposit of phosphate about 0.5 meter thick and carrying about 62 per cent of tricalcium phosphate. Production increased from 2,500 tons in 1910 to 8,400 tons in 1915. This is a French possession.

Christmas Island (Straits Settlements).—On Christmas Island, which lies in the Indian Ocean 190 miles south of Java, rock carrying 80 per cent of bone phosphate is quarried and shipped to Australia and Japan. The deposits seem to be irregular but are estimated to contain several million tons of very high-grade rock. The island belongs to the government of Singapore. Exploitation of the deposits by the British began in 1900. The exports in 1913 were 150,000 tons.

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Ocean Island.—Phosphate rock of high grade is mined on Ocean Island, which is in Gilbert Archipelago, between the Marshall and Solomon Islands, east of New Guinea and north of New Zealand. On this and other coral islands in the equatorial belt which for ages have been rookeries of sea birds, leachings from the guano have impregnated the limestone, forming phosphate rock many feet deep. The deposits on this island, which are said to contain many millions of tons, are among the richest in the world. They have been operated since 1901, and have produced as much as 300,000 tons in a year. The output in 1916 was 70,000 tons of rock carrying about 85 per cent of tricalcium phosphate. This island is a British possession.

Pleasant Island.—Another British possession in the Gilbert Archipelago containing phosphate rock is Pleasant Island, which is also known as Nauru, Naru, or Ngaru Island. The deposits are similar to those on Ocean and Christmas Islands, being very high in calcium phosphate and low in iron and alumina. Germany formerly owned this island, but its interests were liquidated by the British in 1917.

Makatea Island.—Makatea, near Tahiti, in the Society Islands, is estimated to contain 10,000,000 tons of very high-grade phosphate rock irregularly distributed between reefs and pinnacles of dolomite. The deposits were developed so recently as 1910 and yielded more than 300,000 tons before 1917. Some of the rock carries 85 per cent of lime phosphate. The island is a French possession.

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The following papers relating to phosphates have been published by the United States Geological Survey or by members of its staff.

The Government publications, except those to which a price is fixed, may be obtained free by applying to the Director, United States Geological Survey, Washington, D. C. The priced publications may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C. Those indicated as "out of print" are not available for distribution. Geological Survey publications may be seen at the larger public libraries and the libraries of the larger educational institutions throughout the country.

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GRAPHITE.

By HENRY G. FERGUSON.

INTRODUCTION.

Graphite occurs in nature in two forms, crystalline and amorphous, and each form has its own peculiar uses. The term crystalline or flake graphite is commonly understood to mean graphite in crystals large enough to be visible to the naked eye; much of the graphite called amorphous in the trade shows a crystalline structure under the microscope. Crystalline graphite occurs either in veins, as in the Ceylon deposits, or as flakes disseminated through the country rock, as in most of the deposits of crystalline graphite in the United States.

Amorphous graphite may occur wherever coal or other carbonaceous beds have been altered through the influence of neighboring bodies of igneous rock or of movements within the earth's crust. Crystalline graphite, both flakes and vein, is usually associated with granitic intrusives.

DOMESTIC PRODUCTION.

CRYSTALLINE GRAPHITE.

The sales of domestic crystalline graphite in 1918 were larger than ever before. The necessity for conserving shipping made it desirable that imports should be reduced as far as practicable, and the domestic industry responded well to the demand made upon it.

Domestic crystalline graphite sold in the United States, 1916–1918.

	1916		1917		1918	
	Quantity (pounds).	Value.	Quantity (pounds).	Value.	Quantity (pounds).	Value.
Alabama	5,226,940	$492,407	6,223,095	$719,575	7,795,475	$999,152
New York	(a)	(a)	2,941,040	261,548	3,266,518	273,188
Pennsylvania	1,095,716	103,377	804,945	77,475	1,016,900	112,059
Other States [b]	4,609,333	318,964	615,000	35,800	782,946	70,400
	10,931,989	914,748	10,584,080	1,094,398	12,861,839	1,454,799

[a] Included in "Other States."
[b] 1916: California, Montana, New York, Texas; 1917: Alaska, California, Montana, Texas; 1918: California, Montana, Texas.

Total shipments of crystalline graphite in 1918, including both flake and dust, amounted to 12,861,839 pounds, valued at $1,454,799. As mine stocks were approximately the same at the beginning and

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end of the year, this represents about the mine production. The sales show an increase of 22 per cent by weight and 33 per cent by value over those for 1917.

Estimates furnished by the producers of crystalline graphite show that out of the total sales of 12,861,839 pounds, 9,811,046 pounds, valued at $1,364,600, or 76 per cent by weight and 94 per cent by value of the total, was flake graphite for the most part suitable for crucible use. The remainder, 3,050,793 pounds, valued at $90,199, was dust or low-grade flake, probably averaging less than 50 per cent of graphitic carbon. The proportion of flake produced was higher than in previous years, owing in part to improved milling methods, whereby a larger proportion of the graphite was saved as flake, and in part to the fact that high freight rates and lack of demand made it unprofitable in many places to attempt to save the lower-grade graphite of the ore.

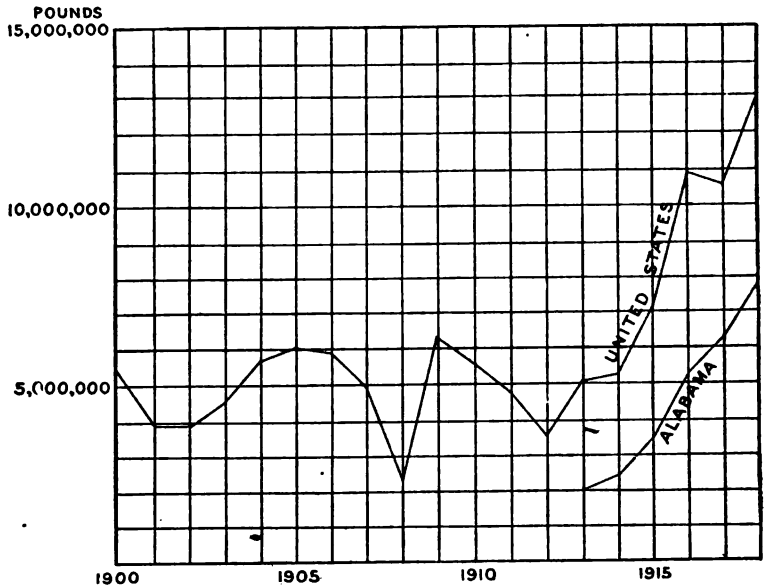

FIGURE 52.—Diagram showing production of crystalline graphite in the United States, 1900–1918, and in Alabama, 1912–1918.

As usual, the greater part of the domestic crystalline graphite was produced in Alabama, New York, and Pennsylvania. The product in these States was all of the variety known in the trade as flake graphite, which occurs as small flakes forming 3 to 10 per cent, by weight, of crystalline schists. In addition, crystalline graphite, resembling in a general way the Ceylon graphite, was produced in Montana, and a small quantity of flake graphite was mined in California and Texas. The number of mines reporting sales of crystalline graphite was 26 in Alabama, 1 in California, 1 in Montana, 3 in New York, 6 in Pennsylvania, and 2 in Texas.

In the first few months of 1918 the domestic industry was in a very difficult situation. The selective draft and the great increase of wages in other industries had caused an acute shortage of labor, particularly in Alabama, and the exceptionally severe winter had

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also curtailed production greatly. Difficulty in obtaining fuel was also a serious factor in some places. The principal difficulty, however, was the freight embargo made necessary by the congestion of railroad traffic. The mines were able to make only small shipments under special license, and even those manufacturers who had been using domestic graphite were of necessity compelled to accumulate large stocks of imported material. Graphite was placed in classification "G" of commodities excepted from embargo on February 11, 1918,[1] and the situation improved somewhat, although the accumulated foreign stocks made the demand rather slack, and the continued shortage of labor increased the difficulty of production. Shipments of domestic flake during the first quarter of 1918 were less than 250 tons per month.

It soon became evident that the necessity for conserving shipping would require a restriction of imports. The War Trade Board, therefore, on March 23, 1918, prohibited imports of graphite by sea after April 15 until July 1 and authorized the importation of 5,000 long tons for the remainder of the year. These restrictions did not apply to graphite from Canada and Mexico. By a subsequent ruling nearly 1,000 long tons was licensed for import before July 1 and 1,200 tons for shipment from overseas ports during the last six months of the year. As it appeared that the stocks of imported graphite were sufficient to last the remainder of the year, a ruling was issued on July 2 prohibiting further imports during 1918. As dealers already had large stocks on hand the response of domestic production was gradual. Shipments of domestic flake for the second quarter of 1918, however, averaged over 300 short tons per month, and in July these shipments exceeded 600 short tons. The War Industries Board on August 10 requested all makers of crucibles to use 20 per cent domestic or Canadian flake in their crucible mixtures for the remainder of the year and 25 per cent during 1919, and stated that future applications for import licenses would be approved only for manufacturers complying with this request. On October 2 the War Trade Board issued a ruling permitting importations of graphite of crucible grade for manufacturers whose application had been approved by the War Industries Board. The requirement of 20 per cent of domestic flake immediately created a considerable demand for domestic flake and shipments from August to November averaged more than 500 short tons per month and would probably have been larger but for the epidemic of influenza. After the signing of the armistice the demand naturally fell off sharply, and domestic shipments were only about 240 tons per month during December, 1918, and January, 1919.

The War Trade Board on November 7 announced that the import restrictions were to continue in force until June 30, 1919, but on January 16, 1919, reversed this decision and removed all restrictions. The domestic producers, therefore, face competition from Madagascar and Ceylon, where large stocks have accumulated. At the same time the demand for graphite of crucible grade has fallen to a fraction of its war-time figure, and there seems no hope for any immediate increase in consumption for use in crucibles. The stock of flake graphite, exclusive of dust, on hand at the mines January 1, 1919, was approximately 1,000 short tons.

[1] U. S. Railroad Administration, Circular C. S. 1.

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Domestic natural graphite sold, 1913–1918.

Year.	Amorphous.		Crystalline.		Total.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
1913	2,243	$39,428	2,532	$254,328	4,775	$293,756
1914	1,725	38,750	2,610	285,368	4,335	324,118
1915	1,181	12,358	3,537	417,273	4,718	429,631
1916	2,622	20,723	5,466	914,748	8,088	935,471
1917	8,301	73,481	5,292	1,094,398	13,593	1,167,879
1918	6,560	69,455	6,431	1,454,799	12,991	1,524,254

AMORPHOUS GRAPHITE.

The sales of domestic amorphous graphite during 1918 amounted to 6,560 short tons, valued at $69,455, as compared with 8,301 tons valued at $73,481, in 1917, and 2,622 tons, valued at $20,723, in 1916. The increased use of graphite in foundry facings has absorbed the increased output in this country as well as much imported amorphous graphite, chiefly from Mexico. The dust obtained as a by-product in the concentration of flake graphite and the artificial amorphous graphite produced in the electric furnace are competitors of the natural product. Sales of amorphous graphite were reported from four mines in 1918, as against six in 1917. The producing States were Colorado, Nevada, and Rhode Island. On account of the small number of producers, figures showing the production by States can not be published without disclosing individual returns.

MANUFACTURED AND SECONDARY GRAPHITE.

Graphite is manufactured chiefly by the Acheson Graphite Co., which utilizes electric power generated at Niagara Falls. The output has increased greatly in recent years and now forms an important element in the country's supply of graphite. The bulk graphite is made either from anthracite or from petroleum coke and is utilized mainly in lubricants but also for paints, foundry facings, boiler-scale preventives, and battery fillers. A high degree of purity is claimed for the lubricating graphite manufactured in this manner.

Artificial graphite may be used for any purpose to which natural graphite is put except in the manufacture of large crucibles. Recently, however, patents have been granted for methods of manufacturing crucibles in which artificial graphite may be employed. Under one method [1] a mixture of either natural, flake, Ceylon, or artificial graphite, fused bauxite (aloxite, alundum), and clay is used. The second method [2] is similar except that zirconia is used instead of fused bauxite.

Besides the graphite products in which artificial graphite enters into competition with natural graphite, there are a large number for which artificial graphite is particularly adapted. Chief among these are graphite electrodes, which are not made from natural graphite and the demand for which has greatly increased during recent years.

[1] U. S. patent 1289578, Dec. 31, 1918.

[2] U. S. patent 1289996, Dec. 31, 1918.

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The figures given below represent only the manufactured graphite that comes into competition with natural graphite.

Graphite manufactured by the Acheson Graphite Co., 1915–1918.[1]

	Pounds.
1915	5,084,000
1916	8,397,281
1917	10,474,649
1918	9,182,272

Some work has recently been done on the commercial recovery of graphite from "kish." G. D. Dub, of the Bureau of Mines, recently visited a mill where "kish" graphite was being concentrated, and the following notes are quoted from his report.[2]

> The product known as "kish" is a mixture of graphite, slag, iron oxide, fragments of iron, and other materials that accumulate about a pig-iron casting ladle or a Bessemer or open-hearth furnace. The graphite is formed during cooling by the crystallization of excess carbon from molten pig iron. The "kish" obtained for refining has contained 8 to 10 per cent of graphite carbon in the form of a light, thin, and fluffy flake.
>
> The method of concentrating and refining "kish" is similar in many ways to the methods employed with natural graphite. The chief points of difference are that "kish" is not subjected to crushing, but is carefully screened and treated with magnetic separators.
>
> "Kish" as a possible source of graphite should not be overlooked. At the present time, however, it is questionable whether enough of this material can be obtained to interfere or compete seriously with the mining of natural flake graphite.

Samples of the finished graphite received by the Geological Survey show a very clean, though light and thin flake, which should be excellent for lubrication.

A small quantity of high-grade graphite has been recovered from old crucibles by Harry Schmehl, of Chester Springs, Pa. The crucibles are crushed in a small mill and the graphite is recovered by oil flotation. Old graphite crucibles are also crushed and used in the manufacture of foundry facings but without separating the graphite from the matrix.

IMPORTS.

The following table shows the imports of graphite into this country since 1913. As the war has disarranged the usual trade routes and as the statistics of the Bureau of Foreign and Domestic Commerce necessarily show only the country from which shipments were made, it is necessary to draw some inferences as to the country of origin. Graphite entered in the import statistics as coming from France is probably all of Madagascar origin, and all graphite imported from Great Britain has been assigned to Ceylon, although it may include a small quantity of Madagascar graphite. Similarly, shipments from Japanese ports are assumed to represent Chosen graphite, as the production of graphite in Japan is small. The imports from Canada in 1914 and 1915 were in excess of the Canadian production for these years, so it is possible that these imports include reexported material.

Imports of doubtful origin are placed under "Other countries." Under this heading is included a small quantity from the Dutch East Indies, which is reported to have been crystalline graphite originating in Chosen.

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[1] Figures published by permission of the Acheson Graphite Co.
[2] Dub, G. D., Bur. Mines War Min. Inv. Ser. 3, p. 17, 1918.

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Graphite imported into the United States, 1913–1918.[a]

[General imports.]

Country of origin.	Quantity (short tons).					
	1913	1914	1915	1916	1917	1918
Ceylon	16,996	8,882	14,491	26,232	24,575	9,029
Madagascar		349	1,468	1,631	4,393	970
Canada	1,662	1,806	2,995	4,127	3,476	3,084
Brazil				1	18	45
Mexico	4,435	4,259	1,680	5,331	7,570	5,000
Chosen (Korea)	4,170	6,327	2,373	5,375	2,462	568
Italy	236	254	27	151	115	17
Austria	660	78				
Germany	90					
Other countries	630	47	41	169		185
	28,879	22,002	23,075	43,017	42,609	19,498

Country of origin.	Value.					
	1913	1914	1915	1916	1917	1918
Ceylon	$1,674,764	$972,408	$1,826,238	$6,356,532	$7,179,208	$2,397,735
Madagascar		38,704	184,067	241,863	1,057,081	265,338
Canada	98,665	92,536	116,407	314,177	349,034	236,226
Brazil				75	4,380	7,351
Mexico	198,000	190,075	75,000	288,000	285,568	134,183
Chosen (Korea)	58,199	96,433	35,292	103,619	83,558	24,455
Italy	4,061	3,203	994	4,133	3,092	628
Austria	9,957	1,258				
Germany	4,034					
Other countries	62,111	3,644	3,165	21,484	67	26,559
	2,109,791	1,398,261	2,241,163	7,279,883	8,961,988	3,092,475

[a] Compiled from records of the Department of Commerce.

Because of scarcity of shipping and of restrictions on importation, imports of graphite were smaller in 1918 than in any other year since 1908.

Graphite imported for consumption in the United States, 1907–1918.

Year.	Quantity (short tons).	Value.	Year.	Quantity (short tons).	Value.
1907	22,939	$1,777,389	1913	28,879	$2,109,791
1908	11,456	762,367	1914	21,990	1,398,209
1909	21,267	1,854,459	1915	23,075	2,241,163
1910	25,235	1,872,502	1916	42,930	7,279,884
1911	20,702	1,495,729	1917	42,577	8,961,988
1912	25,643	1,709,337	1918	19,498	3,092,475

EXPORTS.

Exports of graphite from the United States are comparatively small. In 1915 and 1916 there was a considerable increase in the exports of manufactured graphite articles and a marked decrease in the exports of unmanufactured graphite. During 1917, however, exports of unmanufactured graphite increased greatly and exports of graphite manufactures declined. Exports of both classes declined during 1918. The exports of pencils, which are not included in the classification of articles of manufactured graphite, has increased in recent years. Statistics of exports of pencils are given on page 235.

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Graphite exported from the United States, 1912–1918.

Year.	Unmanufactured graphite.		Manufactures of graphite.
	Quantity (pounds).	Value.	
1912	4,640,802	$333,458	$177,062
1913	5,383,961	391,906	238,302
1914	3,920,693	277,386	215,878
1915	1,057,764	52,583	536,572
1916	1,595,608	98,118	1,339,259
1917	5,146,816	349,563	901,687
1918	1,907,719	121,555	731,518

Graphite crucibles, graphite, and articles manufactured therefrom were removed from the export conservation list on December 6, 1918.

PRICES.

Domestic flake graphite brought slightly lower prices for the best grades and rather higher prices for the lower grades in 1918 than in 1917; the average price on all crystalline graphite sold was higher owing to the greater proportion of high-grade material. The average prices received at the mines for all grades ranged from 10 to 17¾ cents a pound for No. 1 flake; from 7 to 13 cents a pound for Nos. 2 and 3; and from 1 to 1.8 cents a pound for dust. Flake graphite containing about 90 per cent of graphitic carbon sold for prices ranging from 15 to more than 18 cents a pound, and the graphite containing 85 per cent of graphitic carbon, which formed the bulk of the output, sold at 10 to 15½ cents—probably the greater part at 14 to 15 cents a pound. A small quantity of No. 1 flake with a content of graphitic carbon lower than 85 per cent brought prices ranging from 8 to 11 cents. During October some sales of Alabama graphite were made on a basis of 15½ cents a pound for material containing 85 per cent of graphitic carbon, with an allowance of 1 cent a pound for each per cent of graphitic carbon above that figure.

In general prices were lower during the early part of the year than in the summer and reached their maximum in September and October. Since the armistice there has been very little demand. Alabama graphite was quoted early in 1919 at 9 to 12 cents a pound, according to grade, but some sales have been made at higher figures.

The average prices received at the mines for No. 1 flake have been as follows: 1911 to 1914, 6 to 8 cents a pound; 1915, 7 to 10 cents; 1916, 10 to 16 cents; 1917, 12 to 18 cents; 1918, 10 to 17¾ cents.

Ceylon graphite of the better grades is more largely used by crucible makers than domestic flake graphite and commands a higher price. During the war the tremendous increase in manufacture of crucibles caused a demand for the Ceylon product much in excess of the available supply, and the price increased greatly over pre-war figures. The following table showing prices of Ceylon graphite c. i. f. New York for the years 1914–1918, is based on information furnished to the War Trade Board by importers.

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Average prices of Ceylon graphite c. i. f. New York, 1914–1918.

[Cents per pound.]

Year.	Lump.		Chip.		Dust.		Remarks.
	First grade.	Second grade.	First grade.	Second grade.	First grade.	Second grade.	
1914.....	6½– 9½	7½– 8½	7½– 7¾	6½– 7	4¾– 5½	3½– 4	Low, first half; high, second half.
1915.....	9¾–20	8 –14	7–14	6½–12	7½– 9½	6½– 9½	Do
1916.....	20 –28	14 –21	13½–20	11½–17	9½–12	9½–10	Do.
1917.....	28 –32	21 –23	20 –23	17 –19	11 –13	10 –12	High level maintained throughout the year.
1918.....	28½–15½	22 –14	21½–12½	18½–11	12 –10½	10 – 9	High, first half; low, second half.

It is believed that most of the purchases of Ceylon lump during 1918 were made at prices ranging from 21 to 24 cents a pound; chip, 15 to 20 cents a pound; and dust, 6 to 12 cents a pound. The customs figures give an average declared valuation of 13.3 cents a pound at the port of shipment for all Ceylon graphite imported in 1918.

In 1918 Madagascar graphite entered the market in quantity only during the first four months. Sales to consumers were made at 15 to 18 cents a pound for crucible flake. Had import licenses been freely granted, prices would hardly have exceeded 12 cents a pound. London prices for Madagascar graphite have been quoted in the Mining Journal (London) during 1918, and the following is a summary of these quotations:

January 5 to July 20, inclusive: 1,250 francs per ton f. o. b. Marseille for 80 per cent material and 900 francs per ton f. o. b. Tamatave for 85 per cent material, in each case with an allowance of 15 francs per unit of variation.

July 27 to November 30, inclusive: £50 per ton c. i. f. United Kingdom ports for 80 per cent material, with similar allowance for variation.

December 7 to 21, no quotations.

December 28: £46 per ton c. i. f. United Kingdom ports.

Prices for Canadian graphite averaged about the same as for similar grades of domestic graphite. Reports from consumers give 9 to 16⅔ cents a pound as prices paid for flake and three-fourths of a cent to 3¼ cents for dust. The customs figures give an average declared valuation of 3.8 cents a pound for graphite imported from Canada in 1918.

Domestic amorphous graphite brought widely varying prices, according to the grade of the material mined. Although the demand was generally good, the prices do not appear to have increased greatly during the year. The average price for sales at the mines was $10.59 a ton and the range in price was from $5 to $20 a ton. Most of the amorphous graphite on the market was of Mexican origin. This sold at widely varying prices according to the grade, from $35 to more than $100 a ton. Very little Chosen graphite was put on the market in 1918, owing to import restrictions. Some sales at $60 a ton were reported.

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USES.

The following table shows the estimated proportion of graphite consumed in this country for different purposes. As compared with a similar table published some years ago [1] it shows relative increases in the graphite used for foundry facings and relative decreases in the graphite used for crucibles and stove polish. The percentage of graphite used for crucibles was probably considerably higher during the war. The writer desires to thank Mr. Charles E. Pettinos, 25 Church Street, New York, and Mr. Harry Dailey, of the Joseph Dixon Crucible Co., Jersey City, N. J., for assistance in the preparation of this estimate.

Estimated percentages (by quantity) of natural graphite consumed in the United States for various purposes.

	Per cent.
Crucibles	45
Foundry facings	25
Lubricants	10
Pencils and paints	5
Stove polish	5–10
All other uses	10– 5
	100

If artificial graphite were included, the percentages would be less for crucibles and greater for lubricants. If value rather than quantity is considered, about 70 per cent of the consumption should be credited to crucibles.

CRUCIBLES.

Graphite for making crucibles should be of the crystalline variety and should have a high degree of purity. Most makers of crucibles prefer to use Ceylon graphite either alone or mixed with varying proportions of American flake, usually not exceeding 25 per cent of the mixture. The reason for this preference is in part because the more nearly cubical fragments of Ceylon graphite have a much smaller surface area in proportion to their volume than the thin flakes of domestic graphite and hence require proportionately less clay as a binder. Ceylon graphite is also said to be more nearly free from undesirable impurities, such as mica and pyrite. It is possible, however, to use domestic flake graphite alone with good success in crucible manufacture.

Specifications as to graphite for use in crucibles vary widely. The standard for purity ranges from 85 to 90 per cent graphitic carbon and the lower limit of size from No. 12 silk bolting cloth (125-mesh) to No. 8 (86-mesh).

Dub [2] suggests the following specification for American graphite for use in crucibles:

> It is recommended that the graphitic carbon content of No. 1 flake be not less than 85 per cent. By graphitic carbon is tentatively meant the carbon remaining after the dried sample has been burned for three minutes at 800° C.

[1] Bastin, E. S.: U. S. Geol. Survey Mineral Resources, 1913, pt. 2, p. 188, 1914.
[2] Dub, George D., Preparation of crucible graphite; Bur. Mines War Min. Inv. Ser. 3, pp. 20–21, December, 1918.

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The following tentative specifications as to screen analysis for No. 1 flake are recommended in cumulative percentages:

	Per cent.
Over 35 standard mesh	3
Over 65 standard mesh	50
Over 100 standard mesh	100

The following screen analyses of various types of No. 1 flake show the present practice in this regard:

Cumulative percentages of graphite for use in crucibles.

American No. 1 flake.[a]

	1	2	3	4	5	6	7	8
Over 20-mesh				0.1		0.1		
Over 35-mesh	0.1	2.5	3.3	15.4	5.7	6.7	9.7	8.2
Over 65-mesh	42.0	28.0	31.0	69.6	58.5	56.4	62.2	69.6
Over 100-mesh	94.8	60.0	74.3	95.6	93.0	97.0	92.4	99.7
Under 100-mesh	5.2	40.0	25.7	4.4	7.0	3.0	7.8	.3
Graphitic carbon	82.02	92.09	74.67	.....	86.18	86.30	.....	92.43

American No. 2 flake.[a]

	1	2	3
Over 20-mesh			
Over 35-mesh		0.2	0.1
Over 65-mesh		9.9	.3
Over 100-mesh	10.5	67.6	22.2
Under 100-mesh	89.5	32.4	77.8
Graphitic carbon	80.44	81.43	86.30

Canadian No. 1 flake.[b]

[Average of product from 7 mills.]

Over 20-mesh	1.76
Over 40-mesh	20.32
Over 60-mesh	87.32
Over 80-mesh	95.38
Over 100-mesh	96.48
Under 100-mesh	2.98

[a] Dub, G. D., op. cit., p. 20.
[b] Spence, H. S., Canadian graphite industry; Mines Branch Summary Rept. for 1917, p. 50, 1918.

It has been found in practice that although flake carrying 85 per cent of graphitic carbon can be readily produced, the cost of a product containing 90 per cent of graphitic carbon is very greatly increased. This is owing to the fact that small quantities of quartz, mica, and other impurities are interbedded in the graphite flakes themselves, and the flake must be broken to remove them. Seemingly pure graphite flakes were on analysis found to contain only slightly more than 90 per cent of carbon.[1] A sample of Ceylon graphite prepared for crucible use contained 85.06 per cent of graphitic carbon.[2] In purity, therefore, the American graphite compares favorably with that from Ceylon. The question of the relative value of American and Ceylon graphite for use in crucibles is now being investigated by the Bureau of Mines.

The graphite consumed for crucibles in this country during 1916 and 1917 amounted to about 24,000 tons each year, in large part for use in making munitions. It is probable that more than 90 per cent of the graphite used was of foreign origin. During 1918 the graphite consumed for crucibles was probably not more than 20,000 tons. This decrease was due in part to the increased use of electric steel

[1] Moses, F. G., Refining Alabama graphite for crucible use: Bur. Mines War Min. Inv. Series 8, p. 26, 1918.
[2] Dub, G. D., op. cit., p. 21.

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furnaces and open-flame brass furnaces, in part to the export on war orders of raw materials rather than manufactured finished products, and in part also to the fact that a better quality of crucible was made, thus reducing the quantity of crucible graphite used. The normal peace-time requirements of crucible graphite, as measured by the apparent consumption for the years 1911 to 1913, probably do not exceed 13,000 tons a year. It is probable that the further demand for crucibles will diminish rather than increase. The following table shows the rapid increase in the manufacture of electric furnace steel, while the production of crucible steel has remained essentially stationary.

Steel ingots and castings produced in the United States, 1908–1917, by processes, in gross tons.[a]

	Crucible.	Electric.		Crucible.	Electric.
1908	63,631	.....	1913	121,226	30,180
1909	107,355	13,762	1914	89,869	24,009
1910	122,303	52,141	1915	113,782	69,412
1911	97,653	29,105	1916	129,692	168,918
1912	121,517	18,309	1917	126,716	304,543

[a] Am. Iron and Steel Inst.; Special statistical Bull. 4, 1918.

It is believed that with a return to normal conditions this difference will be further accentuated. Recent developments in the electric furnace as applied to nonferrous alloys also give promise of a decrease in the use of crucibles. It is even stated that the time is ripe for the practical elimination of the crucible from the brass industry.[1] A rocking electric furnace designed in the Bureau of Mines showed costs of operation about one-half that of the coke-fired crucible furnaces used in the same plant.[2] It was found that the cost to melt cupronickel, the most refractory alloy handled at the mint, in an electric furnace was less than half that in the gas-fired crucible furnace.[3]

The armistice found manufacturers and users of crucibles with large stocks on hand, and because of the decrease in use that has necessarily followed it will be some time before these are absorbed. The Bureau of the Census undertook a census of crucible stocks in the autumn of 1918, and an abstract of the returns is given below. It should be noted that figures for expected annual requirements refer to war requirements and that under present conditions the requirements will be much less.

[1] Gillett, H. W., and Rhoads, A. E., A rocking electric brass furnace: Jour. Ind. Eng. Chemistry, vol. 10, p. 459, June, 1918.
[2] Gillett, H. W., and Rhoads, A. E., Melting brass in a rocking electric furnace: Bur. Mines Bull. 171, 1918.
[3] Report of the Director of the Mint; abstract in Eng. and Min. Jour., vol. 107, p. 323, Feb. 23, 1919.

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Stocks of finished graphite crucibles in the United States Oct. 1, 1918.

Owned by—	On hand and in transit.	In use.	Estimated annual requirements.
Manufacturers of crucibles	310,753		
Users of crucibles for work in—			
Steel	72,552	8,626	678,094
Brass, bronze, and aluminum	178,470	14,658	1,058,958
Babbitt metal and solder	1,340	64	6,156
Miscellaneous	20,002	1,985	46,930
	583,117	25,333	1,790,138

It will be seen that even under war conditions the supply of crucibles of all sizes amounted to one-third of the estimated annual consumption. For the smaller sizes, up to No. 45, the total stocks were 111,886 and the estimated annual requirements only 83,841.

FOUNDRY FACINGS.

Next to crucibles, foundry facings probably consume more graphite than any other single use. For this use graphite is commonly mixed with talc or other substances in varying proportions. Amorphous graphite and the dust obtained as a by-product in the refining of flake graphite are used for the manufacture of foundry facings. Old graphite crucibles are also crushed and used for the same purpose. Usually a high degree of purity is not required. The advantages of graphite for this purpose are that it can be readily smoothed, to give a good surface to the mold, and that the combustion is regular but not too rapid, so that the film of gas formed prevents any adhesion of the metal to the sand of the mold, but is not sufficient to cause irregularities in the casting. A rough estimate of the graphite used in the country for foundry facings places the quantity at 10,000 tons a year.

LUBRICANTS.

Graphite for lubrication appears to be in constantly increasing demand. For this purpose freedom from abrasive impurities is the prime consideration. Flake graphite, amorphous graphite, and artificial graphite are all used for lubrication. The graphite may be used either alone or combined with greases and oil, or, as with colloidal graphite, in suspension in oil (oildag) or water (aquadag). Graphitized metals formed by impregnating copper or babbit with graphite are used for bearings and sliding contacts.

The use of graphite in lubrication greatly reduces the cost of operating machinery of any kind and increases efficiency. It is stated that the increased use of colloidal graphite during the war enabled Germany to effect a saving of at least 15 per cent in the quantity of lubricating oil required.[1]

It is difficult to form any close estimate of the quantity of graphite used in this country for lubrication. Probably the annual consumption is less than 3,000 tons of natural graphite, exclusive of artificial graphite.

[1] Chimie et industrie, vol. 1, p. 168, 1918.

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PENCILS.

The use of graphite in "lead" pencils is the most familiar as well as the most ancient use. In the sixteenth century pencils were made in England from the graphite of the famous Borrowdale mine. The graphite was at first cut into strips, and it was not until late in the eighteenth century that the present method of making the "lead" in pencils from a mixture of graphite and clay was adopted. Graphite for making pencils must be free from impurities and finely divided in order to make an even mixture with the clay. Formerly Bohemian graphite was largely used for this purpose, but this has now been superseded by Mexican amorphous graphite.

Prior to the war pencils were imported in large quantities, principally from Germany and Austria. The imports of foreign pencils are now insignificant, and large quantities of pencils of American manufacture are exported to all parts of the world.

Value of pencils and pencil leads exported from the United States, 1918.[a]

[Figures compiled by the Bureau of Foreign and Domestic Commerce.]

Country.	Value.	Country.	Value.
France	$32,326	China	$17,905
Italy	77,240	British India	65,088
Spain	179,706	Straits Settlements	10,148
England	542,720	Dutch East Indies	33,037
Canada	425,927	Japan	50,740
Mexico	104,154	Australia	155,157
Cuba	127,177	New Zealand	20,134
Argentina	166,069	Philippine Islands	96,525
Brazil	110,741	British South Africa	76,901
Chile	58,198	Other countries	85,816
Colombia	12,807		
Peru	26,806		2,497,208
Uruguay	21,886		

[a] Commerce Repts., Apr. 12, 1919, p. 301.

Although the manufacture of pencils is an important industry the quantity of graphite used in it is comparatively small, and the manufacture of pencils in this country does not consume much more than 1,000 tons of graphite a year.

OTHER USES.

Graphite has a wide variety of uses other than those enumerated above. It is used extensively in paints for iron roofs and other iron surfaces and makes a coating that has great permanency. The graphite is commonly mixed with silica. Graphite is used for fillers of dry cells, electrotyper's leads, motor brushes, pipe cement, stove and metal polish, for glazing powder, polishing shot, minimizing water friction on yacht and launch bottoms, and for other purposes. Graphite added to impure boiler water loosens old scale and prevents the formation of scale.

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REVIEW BY STATES.

ALABAMA.

As usual, Alabama led in the production of crystalline graphite. The sales for 1918 amounted to 7,795,475 pounds, valued at $999,152, an increase of 25 per cent in quantity and 39 per cent in value over 1917. Sales of flake greatly exceeded those for 1917, but there was little market for dust and many operators made no attempt to save it.

The year 1918 was marked by improvement in milling methods which have to some extent compensated for the tremendous increase in costs. Alabama milling practice has been described in detail in a recent publication of the Bureau of Mines.[1] At present the average recovery from the Alabama ores, which contain about 2½ per cent of graphite, is about 19 pounds of No. 1 flake, 5 pounds of No. 2 flake, and 3 pounds of dust per ton of ore.

The following companies either reported sales or stated that they had begun the production of graphite in 1918:

Alabama graphite companies.

Company.	Office.	Mine.
Alabama Graphite Co.	Ashland	Ashland.
C. B. Allen Graphite Co.	do	Do.
American Graphite Co.	do	Do.
Ashland Graphite Co.	do	Do.
Atlas Graphite Co.	do	Do.
Axton Noe Graphite Co.	Louisville, Ky.	Do.
Carbon Mountain Graphite Co.	Lineville	Lineville.
Ceylon Graphite Co.	Birmingham	Hollins.
Clay County Graphite Co.	Ashland	Do.
Crucible Flake Graphite Co.	do	Do.
Crystalline Flake Graphite Co.	do	Do.
Diamond Graphite Co.	Alexander City	Goodwater.
Duro-Flake Graphite Co.	Montgomery	Coosa County.
Flaketown Graphite Co.	Mountain Creek	Mountain Creek.
Goodwater Graphite Co.	Goodwater	Goodwater.
Graphite Mills (Inc.)	Ashland	Ashland.
Griesemer Graphite Co.	do	Do.
Hood-Graves Graphite Co.	Alexander City	Do.
Jefferson Graphite Co.	Birmingham	Ashland.
Jennings Graphite Co.	Talladega	Lineville.
Liberty Graphite Co.	Birmingham	Do.
Lineville Graphite Co.	Lineville	Do.
May Brothers Graphite Co.	Ashland	Ashland.
Monitor Graphite Co.	do	Do.
National Flake Graphite Co.	do	Do.
Parkdale Graphite Products Co.	Hollins	Parkdale.
Peerless Flake Graphite Co.	Lineville	Lineville.
Quenelda Graphite Co.	Quenelda	Quenelda.
Republic Graphite Co.	Ashland	Ashland.
Southern Graphite Co.	do	Do.

The Quenelda Graphite Corporation has recently absorbed the following graphite plants in the Alabama field: The Quenelda Graphite Co., American Graphite Co., Crucible Flake Graphite Co., Carbon Mountain Graphite Co., Peerless Flake Graphite Co.

NEW YORK.

The sales of graphite in New York in 1918 amounted to 3,266,518 pounds, valued at $273,188, an increase of 11 per cent in quantity and 4.5 per cent in value over the output in 1917. The ore of the New

[1] Dub, G. D., Preparation of crucible graphite: Bur. Mines War Min. Inv. Ser. 3, pp. 3-12, December, 1918.

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York deposits averages 4 to 6 per cent of graphite, but is harder and more siliceous than the lower-grade Alabama ore.

The following companies in New York reported sales in 1918:

Graphite Products Corporation, Saratoga Springs.
American Graphite Co. (Joseph Dixon Crucible Co., owner), Graphite.
Hooper Bros., Dresden.

The graphite deposits of New York, including prospects and abandoned mines as well as those in active operation at the present time, are described in great detail in a recent report by H. L. Alling.[1] Many microscopic and chemical analyses of the ores are given. Alling divides the deposits into those of the northern area, where most of them are of the limestone and contact type, and those of the southern area, where they are characteristically in the bedded form. The northern area includes the deposits of Essex County and a group of prospects and abandoned mines in Ticonderoga Township. None of the mines in this area are now in operation. In most of these deposits graphite has developed in sedimentary rocks, chiefly limestone, in contact with pegmatite and other igneous rocks. These are too uncertain, too pockety, and too small in extent to be minable under present conditions.

The graphite schists of the southern area at present furnish the commercial deposits of the Adirondacks. These are divided into four groups, as follows:

1. The normal quartz schist, carrying 5 to 7 per cent of graphite. This is the ore mined at present. It exists as two beds in some properties, as one bed in others. It ranges in thickness from 3 to 30 feet. The upper and the lower layers tend to be micaceous, and, as a general rule, the mica content increases with increase in the feldspar content.

2. A feldspar-quartz schist, carrying 6 per cent of graphite and 10 per cent of micaceous minerals.

3. A phase of the quartz schist affected by contact metamorphism, with the development of pyroxene and tourmaline. The graphite has been redistributed, and certain layers show an abnormally high content.

4. A meta-arkose or "arkosite" which consists almost entirely of potash feldspar. Alling's mineral analysis shows 1.6 per cent of graphite in ore of this type.

Present milling practice makes only the material of the first group available as graphite ore. Alling estimates that the properties of Faxon, Hooper Bros., the Flake Graphite Co., and the Graphite Products Corporation have a combined reserve of 10,000,000 to 13,000,000 tons of graphite schist, half of which is readily available. A reserve of 5,000,000 tons of available ore, carrying 3 per cent of recoverable graphite, would yield 300,000,000 pounds of graphite, enough to maintain the present rate of production from this State for nearly a century.

The schist ores are considered to be of organic origin, the change from organic carbon to graphite having been effected by the heat and pressure accompanying mountain building stresses. The contact and vein types are considered to be of inorganic origin, in that the graph-

[1] Alling, H. L., The Adirondack graphite deposits: New York State Mus. Bull. 199, Albany, 1918.

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ite was formed from the breaking up of gaseous oxides of carbon in the pegmatites.

Alling's paper also describes the milling methods in New York. Present milling practice, however, is described in more detail by Dub.[1]

PENNSYLVANIA.

Sales of graphite in Pennsylvania during 1918 amounted to 1,016,900 pounds,[2] valued at $112,059, an increase of 26 per cent in quantity and 45 per cent in value over the output in 1917.

The following operators in Pennsylvania reported sales of graphite during 1918:

T. D. Just Co., Chester Springs.
W. E. Pomeroy, Byers.
E. E. Hargrave, Byers.
Harry A. Schmehl, Chester Springs.
Standard Carbon Co., Pikeland.
Rock Crucible Graphite Co., Chester Springs.

The producing graphite deposits of Pennsylvania are in the vicinity of Byers and Chester Springs, in Chester County. The material chiefly mined is a graphitic schist, rich in lime-silicate minerals. In several mines this rock is deeply weathered, and the soft clayey material can be mined cheaply. Everywhere intrusions of pegmatitic granite are noticeable. The pegmatite is for the most part in thin sills parallel to the schistosity and is barren of graphite except to a small extent near the contact. The mine of the T. D. Just Co. is on the top of the hill about a mile south of the village of Chester Springs. The ore is exposed in a 30-foot open cut and consists of soft weathered material throughout. Considerable pegmatite is present, but for the most part in narrow bands only. The ore is dug by a steam shovel and hauled to the mill a short distance away. The oscillator system [3] is used for concentration.

Across Pine Creek to the northeast a continuation of the same band of graphitic schist has been mined in former years. The mine of the Federal Carbon Co. is about half a mile northeast of these workings and a mile east of Chester Springs. Graphite was formerly mined in open cuts, but the present company is doing underground work. The mine is developed by a shaft 120 feet deep, with drifts about 200 and 100 feet long at the 80-foot level. Even at this depth the ore is weathered.

The quarry of the Rock Crucible Graphite Co. is on the top of a hill about a mile northwest of Chester Springs. In contrast to the material mined farther east, the ore is hard and requires drilling. The workable portion consists of hard schist about 12 feet thick, which dips 30° E. and grades into micaceous material above. Much pegmatite in thin seams parallel to the schistosity is present. The ore is trammed through a tunnel to the mill a quarter of a mile to the north. The electrostatic process is used for concentration.

The Graphite Products Co. is operating a large quarry just south of Byers. Formerly the deposit was mined underground, and the old drifts are still to be seen in the quarry face. The ore, though of unusually high grade in places and weathered throughout, is very

[1] Dub, G. D., op. cit., pp. 12–14.
[2] Includes an estimate for the Graphite Products Corporation, which refused to furnish information.
[3] Dub, G. D., op. cit.

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uneven in tenor, and the best material occurs in thin bands. The largest flakes are in a greenish clayey material, usually close to the pegmatites. About half the face appears to be of pegmatitic material. The mill uses log washers with burr mills for finishing.

The old Tonkin mine, southeast of Byers, has been leased by E. C. Hargrave. The workings consist of a large quarry and of smaller prospects in other parts of the property. Much of the ore is of high grade, and all of it is sufficiently weathered to facilitate mining, but the individual seams of good material do not exceed 10 feet in thickness. Some very large flakes, as much as half an inch in diameter, occur in places. The mill uses oscillators, similar to those at the Just mill, for concentration. The finishing plant consists of screens, rolls, and burr mills for final grinding.

Besides the mining operations in this district, there are two other plants which deserve mention. Frederick B. Chester has a mill near Chester Springs, where the dust from the flake graphite mills, averaging 30 or 40 per cent of graphitic carbon, is refined by a special process to a high-grade product suitable for battery fillers and high-grade lubricants. At Pikeland, Harry Schmehl has a small mill where ore from neighboring mines is treated and graphite is also recovered from old crucibles.

TEXAS.

The following notes on graphite operations in Texas are quoted from the report by Dub already cited:[1]

Three properties are now operating in the State. The Southwestern Graphite Co., 9 miles west of Burnet, and the Burnet-Texas Graphite Co., 7 miles west of Burnet, have developed open pits; the Dixie Graphite Co., 4 miles northeast of Llano, is mining underground.

At the property of the Southwestern Graphite Co., the overburden, which varies in thickness from 2 to 8 feet, is a hard-baked detritus containing large boulders of ore. It contains considerable clay and vegetable fiber and is said to average 3 or 4 per cent graphitic carbon, only a small part of which can be recovered as No. 1 flake stock. Accordingly, this material is now being loosened by means of a plow, aided by a snatch block, and is being disposed of as waste. In loosening overburden of this character, black powder might advantageously be used.

The ore body at present is being crosscut, preliminary to the development of two working faces along the strike of the ore, which is 80 to 100 feet thick and dips about 65° SE. It can be followed on this company's property with a slight interruption for almost three-fourths of a mile along the strike.

In mining, a Keystone wood-fired churn drill is used for drilling holes 5½ inches in diameter. These are placed at the corners of 12-foot squares, the first row of which is 12 feet from the last crack of the previous blast. All holes are drilled to a depth of 25 or 30 feet, which is 5 feet below the elevation of the bottom of the open pit. Blasting gelatin of 60 per cent strength is used for breaking. An Erie wood-fired steam shovel, with a dipper capacity of five-eighths of a cubic yard, loads the broken ore into 5-ton side-dump contractors' cars, which are hauled to the mill by a Whitcomb gasoline locomotive. Large boulders are placed to one side by the shovel and block-holed with self-rotating hammer drills of the "jackhammer" type.

The Burnet-Texas Co., 2 miles northeast of the Southwestern Graphite Co., is operating in a small way on the same graphite schist series. Here, however, the ore contains more frequent granite and pegmatite intrusions, and as now developed appears to contain less graphite that would make No. 1 flake stock. Besides an open pit, this property is now being prospected by a vertical shaft.

The Dixie Graphite Co., 4 miles northeast of Llano, obtains its ore from underground mining. The deposit dips to the southeast at a flatter angle than at the Southwestern Graphite Co.'s property. The ore near the surface contains considerable quantities of amorphous graphite and fine flake. The ore at present mined underground is a

[1] Dub, G. D., op. cit., pp. 16–17.

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better grade as regards the size of flake and contains considerably more pyrite and mica than were obtained in the surface ore. On this property in the past much development work was done with a view to mining gold and molybdenite ores, but these efforts were not successful.

Two plants use the oil-froth flotation methods; at a third plant Huff electrostatic machines have been installed. These plants do not differ materially from mills previously described, except that in each a rough concentrate analyzing 70 to 80 per cent of graphitic carbon and remaining on an 80 or a 90 mesh screen is recovered.

No refining plants are as yet in operation.

* * * * * * *

The Texas district is fortunate in being able to obtain a fair supply of native white labor, which has not been drawn from the district by the attraction of high wages paid in our various manufacturing centers. This labor, of course, is inexperienced in mining but in these times of stress furnishes a more efficient potential supply than is present in the Alabama field.

OTHER STATES.

The California Graphite Co., of Los Angeles, continued its production of flake graphite during 1918. This deposit has been described in detail in a previous report.[1]

The Crystal Graphite Co., of Dillon, Mont., continued its production of high-grade vein graphite of a type similar to the Ceylon product. Deposits of flake graphite in Montana were prospected in 1918, but no production is reported, and it is doubtful whether present market conditions justify the development of flake deposits at so great a distance from the market.

A small quantity of crystalline graphite was mined near Shelby, N. C., by the General Graphite Co., of Birmingham, Ala. The first shipment of graphite was made in January, 1919. This company also reported development work on South Carolina deposits. Specimens of flake graphite have been received from Hickory, N. C.

Samples of good-grade flake have been received from Goochland, Va., where E. M. Gathright is developing a graphite property.

A company was organized to reopen the abandoned graphite deposit at Highbridge, N. J., but did not begin operations.

Rhode Island furnished a large production of amorphous graphite in 1918 from mines near Providence. The graphite has resulted from the metamorphism of coal beds, and is largely used for foundry facings. The operators reporting production were the Graphite Mines Corporation, of New York, and Frank D. Fenner, of Providence. Amorphous graphite was also produced in Colorado by Woodruff & Woodruff, of Greeley, from a deposit in the Quartz Creek district, and in Nevada by the Carson Black Lead Co., of Carson.

FOREIGN DEPOSITS.

WORLD'S PRODUCTION.

The following table shows the world's production of graphite by countries since 1914, so far as statistics are available. Tables of production for 1913 and earlier years have been published in the reports on graphite for 1906 to 1917, inclusive. The production of the leading graphite-producing countries from 1902 to 1918 is shown graphically in figure 53, and the location of the principal graphite deposits of the world is shown in Plate II.

[1] Bastin, E. S., Graphite in 1915: U. S. Geol. Survey Mineral Resources, 1915, pt. 2, pp. 88–89, 1916.

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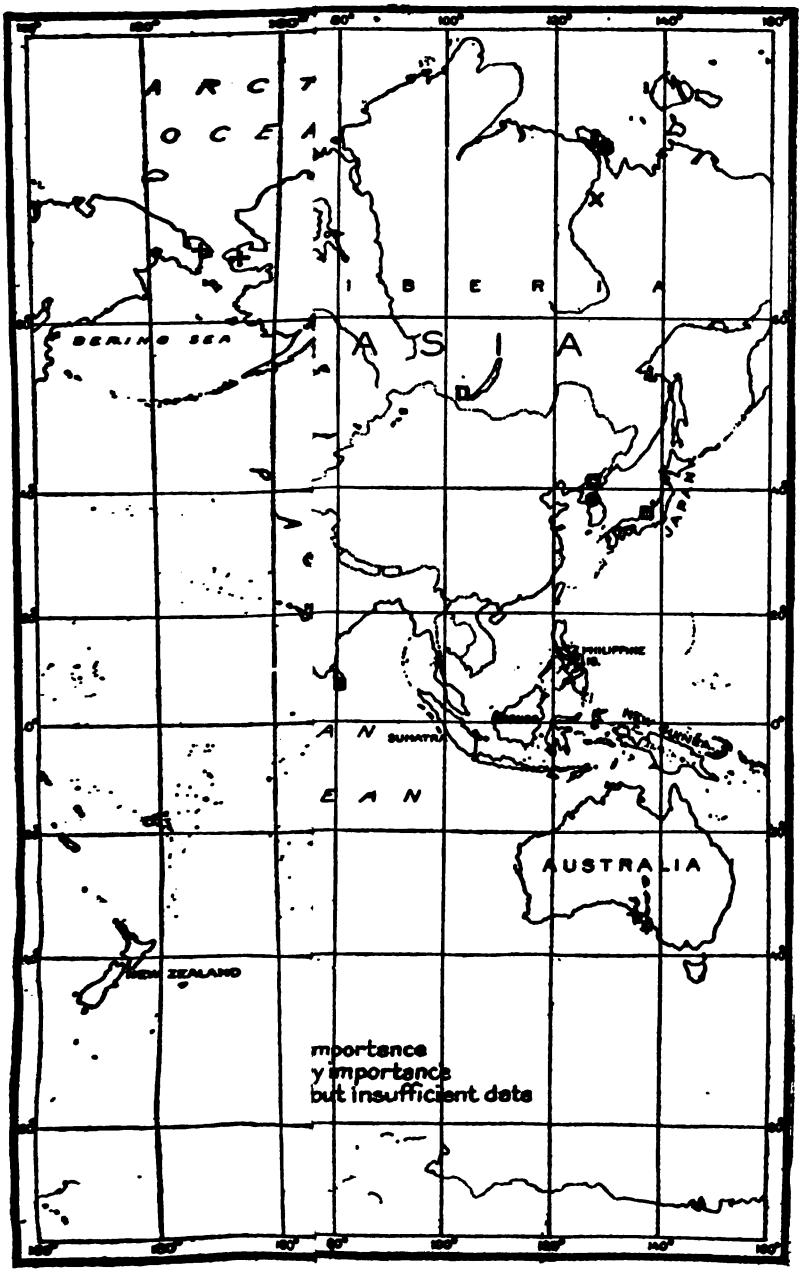

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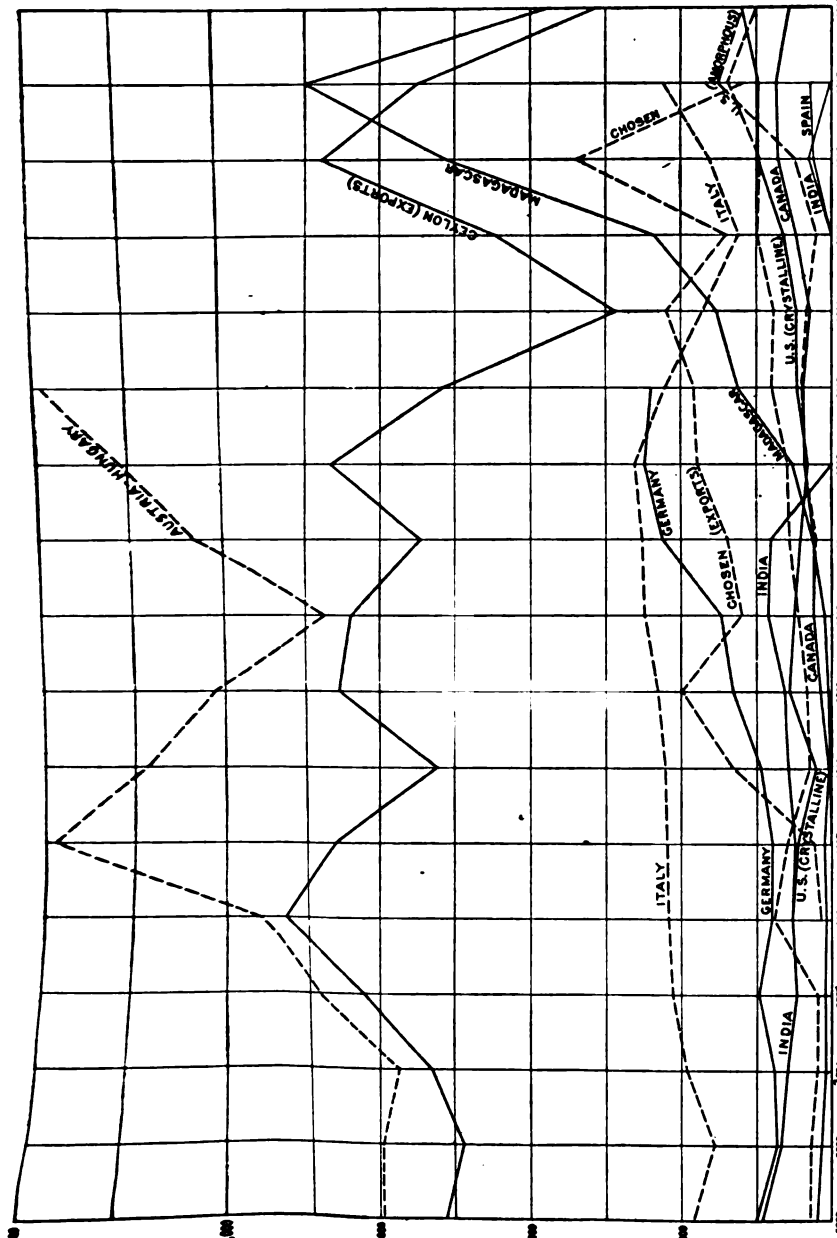

FIGURE 53.—Diagram showing production of graphite in principal countries in 1902–1918. Full lines indicate principally crystalline graphite; dotted lines, principally amorphous graphite. Production of amorphous graphite in the United States prior to 1908 is not included. Figures for production of Chosen from 1909–1912 are estimates based on value of exports.

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World's production of natural graphite, 1914–1918.

Country.	1914		1915		1916		1917		1918	
	Quantity (metric tons).	Value.	Quantity (metric tons).	Value.	Quantity (metric tons).	Value.	Quantity (metric tons).	Value.	Quantity (metric tons).	Value.
United States: [a]										
Amorphous	1,565	$38,750	1,071	$12,358	2,378	$20,723	7,530	$73,481	5,951	$99,455
Crystalline	2,368	285,368	3,209	417,273	4,959	914,748	4,801	1,094,398	5,334	1,454,799
Canada [a]	1,495	107,203	2,391	124,233	3,588	325,362	3,672	402,892	2,826	248,970
Mexico [b]	3,865	190,075	1,525	75,000	4,831	238,000	6,869	285,568	5,080	134,183
Austria [c]										
France [d]										
Germany [e]										
Italy	8,567	50,051	6,176	40,100	8,182	58,349	12,117	141,900	(g)	(g)
Spain			33	30	1,240	1,540	1,980	984	(g)	(g)
Sweden	56	4,140	87	6,432	194	17,956	4	32	(g)	(g)
Ceylon [b]	14,463	1,142,000	22,173	2,569,434	33,956	7,298,128	27,572	7,071,803	15,701	f 2,685,000
India			71	769	1,525	7,344	105	2,660	(g)	(g)
Japan	573	f 156,000	666	f 15,000	1,144	25,903	1,187	(g)	(g)	(g)
Chosen (Korea)	11,000		7,046	101,041	16,948	243,000	6,500	(g)	(g)	(g)
Madagascar	7,749	688,720	11,851	1,053,250	25,490	2,213,000	35,000	3,040,000	16,000	f 1,391,000
South Africa	31	2,977	37	5,856	55	8,657	78	12,596	(g)	(g)
Australia	34	4,718	70	144			71	97	(g)	(g)

[a] Sales at mines.
[b] Exports.
[c] No data. Production in 1913, 49,456 metric tons, valued at $417,745.
[d] No data. Production in 1913, 1,194 metric tons, valued at $3,320.
[e] No data. Production in 1913, 12,059 metric tons, valued at $63,308.
[f] Estimated.
[g] No data.

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NORTH AMERICA.

CANADA.

The Canadian output was slightly smaller in 1918 than in 1917. The greater part of the output comes from the Province of Ontario, where the Black Donald mine, at Calabogie, is the principal producer. This graphite is used largely for foundry facings in the United States. Canadian flake is also used by manufacturers of crucibles, and some of them prefer it to the Alabama flake. The flake graphite occurs in crystalline limestone in Haliburton and Hastings counties, Ontario, where the graphite content ranges from 10 to 15 per cent, and in more or less calcareous bands intercalated with gneiss in the Buckingham district, where the tenor is 7 to 10 per cent.[1] A small output of lump graphite, similar to Ceylon lump, has been obtained from Baffin Island.

The graphite deposit of the Globe mine, in the Port Elmsley district, Ontario, has been recently described by Wilson.[2] Here the graphite is largely concentrated on the crest of an anticline of silicified limestone intruded by pegmatite dikes.

The completely silicified portions of the limestone are richer in graphite, and Wilson considers it probable that the source of the graphite is the carbon content of the original calcium carbonate which formed the limestone.

Most of the Canadian graphite is exported to the United States, but crucibles, foundry facings, and pencils are also manufactured in Canada. Besides natural graphite there is also a production of artificial graphite in Canada, which amounted to 263 short tons in 1916 and to 548 tons in 1917.[3]

MEXICO.

Owing to the exclusion of Chosen graphite by embargo restrictions, Mexican graphite during the greater part of the year was the only high-grade foreign amorphous graphite on the American market. The figures for the Mexican production given in the foregoing table are those for imports into the United States, but they represent the production fairly accurately, as the mines are operated by American companies and the product is refined in this country. Mexican production was low in 1915, owing to the disturbed political condition of the country, but increased in 1916 and 1917.

The decrease in 1918 was due in part to the epidemic of influenza which ravaged northern Mexico in the later part of the year.

The following notes on the Mexican deposits are quoted from the Survey report on graphite for 1913:[4]

> For a number of years the United States Graphite Co. has been an important producer of amorphous graphite from mines in the State of Sonora, Mexico. The crude material is shipped by rail to Saginaw, Mich., where it is ground in continuous feed tube mills and is subsequently air floated. Some of the product is mixed with

[1] Spence, H. S., The Canadian graphite industry: Mines Branch Summary Rept. for 1917, pp. 49–50, 1918.
[2] Wilson, M. E., Graphite in Port Elmsley district, Lanark County, Ontario: Canada Geol. Survey Summary Rept., 1917, pt. E., pp. 29–42, 1918.
[3] McLeish, J., Mineral production of Canada, 1917; Mines Branch, 1918.
[4] Bastin, E. S., U. S. Geol. Survey Mineral Resources, 1913, pt. 2, pp. 244–245, 1914.

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greases to make a prepared lubricant or with other pigments and oil for black, dark-green, and dark-brown paints. The remainder is marketed in the dry state for practically all the purposes to which any graphite is applied, except the manufacture of crucibles and related refractory products.

The following description of the graphite mines of Sonora, Mexico, has been furnished by Frank L. Hess, of this Survey, who visited these properties early in 1909:

"The Santa Maria graphite mines, which are owned by the United States Graphite Co., of Saginaw, Mich., are situated about 20 miles south and a little east of La Colorada, in central Sonora. They are the largest amorphous-graphite mines in the western hemisphere and probably in the world. The country rock is composed of metamorphosed sandstone, ranging in fineness from shaly material to conglomerate containing pebbles of 1½ inches diameter. Considerable andalusite in small crystals is developed in the sandstone. The rocks are probably of Upper Triassic age. They are intruded by granite, which has been the metamorphosing agent. Intercalated with the sandstone are at least seven beds of graphite, ranging in thickness up to 24 feet and standing at high angles. The rocks are considerably folded, and the graphite beds show the effect of movement more than the inclosing sandstone; in places they are almost cut off through squeezing, while in other places they show thickening. The graphite beds are also intruded by granite dikes, and in places the walls are of granite. The graphite was undoubtedly formed through the metamorphism of coal beds, which in other parts of the State are to be found in the form of coke, anthracite, and bituminous coal. The graphite of the Santa Maria deposits is entirely amorphous, and from the main vein worked averages about 86 per cent graphitic carbon. Specimens may be picked which carry 95 per cent graphitic carbon. The graphite is shipped to Saginaw, Mich., for refining. A large part of the best pencils, both of European and American manufacture, are made from this graphite. It is also used as a lubricant, for powder coating, and for foundry facings. A few miles north of Torres, and 3 miles west of the railroad, Pettinos Brothers, of Bethlehem, Pa., own graphite deposits, for which a good price was paid a few years ago. A small amount of graphite was shipped, but the property is now lying idle. Prospecting is being carried on for graphite on the east side of Yaqui River, a few miles above Onavas. The geology is similar to that of the deposits at Santa Maria, about 75 miles west. At San Marcial, between Santa Maria and Onavas, coal is found partly graphitized; and at points on Yaqui River above Onavas unaltered coal beds are reported, which, it is said, the Southern Pacific controls and will use for fuel on its Mexican lines."

SOUTH AMERICA.

BRAZIL.

A little crystalline graphite has been imported into this country from Brazil, but no data are available as to the production. Graphite is reported to be found in considerable quantities in the State of Sao Paulo [1] but has not yet become commercially important. Graphitic schists containing 10 to 11 per cent of carbon are mined in the State of Rio, and the material is used locally for the manufacture of pencils.[2] Graphite appears to be abundant in Minas Geraes, particularly in the Lafayette district, where it occurs in graphitic schists and also in veins ranging in width from a few millimeters to about a meter.[3] These deposits do not appear to have been worked.

A number of deposits have been located in different parts of the State of Bahia but have never been developed. Deposits of flake graphite are known at Cachoeira, Castro Alves, and Jaquitionha River, and amorphous graphite is found at Nazareth, Camisao, Santa Luzia, and Areia.[4] At Nazareth the graphite occurs in connection with manganese deposits.[5] Veins of graphite 19 to 40 inches thick containing masses weighing hundreds of pounds are

[1] Commerce Repts. 40a, p. 16, Sept. 25, 1917.
[2] Oakenfull, J. C., Brazil in 1913, p. 444, 1914.
[3] Derby, O. A., On the manganese ore deposits of the Queluz (Lafayette) district, Minas Geraes, Brazil; Am. Jour. Sci., 4th ser., vol. 12, pp. 18-32, 1901. See also Oakenfull, J. C., op. cit., p. 444.
[4] Higgins, E., United States consul, Bahia, report Apr. 9, 1917.
[5] Derby, O. A., Manganese ore deposits of Brazil: Am. Jour. Sci., 4th ser., vol. 12, p. 32, 1901.

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reported to occur at Emparedado, in Bahia, but lack of transportation has prevented development.[1]

URUGUAY.

Graphite has been mined near Isla Mala, in the department of Florida, Uruguay, and deposits are known in other parts of the country.[2] The graphite is said to be of poor grade, and there are no mines at present in operation.

CHILE.

Undeveloped graphite deposits of possible importance occur near Castro on the island of Chiloe and at Chepueque in the Province of Atacama, Chile.[3]

EUROPE.

AUSTRIA-HUNGARY.

The former Austro-Hungarian Empire led the world in the production of graphite, measured by quantity. This output, however, consisted entirely of armorphous graphite, for the most part of low grade. The production in 1913 amounted to 39 per cent of the quantity of the world's output but to only 9 per cent of the value. The graphite occurs in Bohemia, Moravia, Lower Austria, and Styria, and the reserves appear to be very large. The first two regions are included in the new State of Czecho-Slovakia, and the Lower Austrian and Styrian deposits are in German Austria.

The most productive deposits are those of southern Bohemia. Many others are found in the mountain range that forms the border between Bohemia and Moravia, chiefly on the Moravian side. A group of deposits of probably less value occurs in the lower Austrian hills, on both sides of the Danube. West of Vienna and in the Styrian Alps there are some deposits which at present rank second only to the Bohemian deposits in production.

The Schwarzback-Krumau district, in southern Bohemia, yields about two-thirds of the Bohemian output. The mines have been worked since 1790 and appear to have passed their maximum productivity. However, there is said to be a large area of undeveloped ground. The graphite occurs in irregular lenticular masses of graphite schist interbedded with other metamorphic rocks. The graphite, which as produced contains only about 60 per cent of carbon, is used for foundry facings and the cheaper grades of pencils. The Kollowitz district yields a slightly better grade of graphite, but its output is smaller. The graphite of the Smojanow district, close to the Moravian border, is said to be of poor grade and to carry much pyrite.

The Moravian deposits occur for the most part close to the Bohemian boundary southward from the frontier of Prussia. The most important are those of Altstadt, Kunstadt, Muglitz, and Oels. In

[1] Oakenfull, J. C., op. cit., p. 444.
[2] Marstrander, R., Preliminary report on the mineral resources of Uruguay, pp. 36-37, 1916.
[3] Miller, B. L., and Singewald, J. T., jr., The mineral deposits of South America, p. 325, 1919

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the Altstadt district beds of impure graphite with a workable thickness of more than a meter underlie an area of 10 square kilometers. The graphite is impure and of the amorphous variety, and is used chiefly for foundry facings. The production is probably about 5,000 tons of raw material a year. In the Kunstadt district two beds of graphitic schist have been mined since 1903. The graphite is used in pencil and paint manufacture. The Muglitz district has been known since 1567, and the deposits have been mined more or less systematically since 1847. The graphite occurs in graphitic schist, which has a tenor of 32 to 42 per cent of carbon. The thickness of the bed ranges from 0.5 to 20 meters, in most places 0.75 to 1 meter. The deposit has been developed to a depth of 106 meters. The graphite is used for pencils and foundry facings. Formerly graphite from this deposit was exported to America for the manufacture of pencils. The graphite of the Oels district is similar to that of Muglitz, but the possible reserves are much larger, as three beds, 5, 6, and 11 meters thick, are known. The graphite is said to carry considerable pyrite and is suitable only for pencils and paints.

The graphite deposits of Lower Austria occur in a small area between 65 and 90 kilometers west of Vienna. The graphite is all of poor grade, and the production is small. The only districts of importance appear to be those of Muhldorf and the Dunkelsteiner Wald The Muhldorf deposit consists of a bed of impure graphite from 10 to 40 meters thick associated with crystalline limestone dipping steeply to the southeast. As early as 1855 this bed had been developed to a depth of 160 meters. In 1909, however, only one mine was in operation. The deposit in the Dunkelsteiner Wald consists of graphite lenses of varying purity in crystalline limestone. In part the graphite is crystalline and very pure. After being abandoned for some years the deposit was reopened in 1907 by a Belgian company. The product was used chiefly for the manufacture of pencils.

The graphite deposits of Styria occur in a belt 50 kilometers long extending from Kaiserberg, near Leoben, to Rottenman. The graphite has resulted from the metamorphism of coal beds and in places grades into anthracite. Several beds 6 meters in maximum thickness are worked. The production of the district has shown a steady increase from 400 tons in 1866 to 14,031 tons in 1912. As silica is the only impurity, the graphite, although amorphous, can be used in the poorer grades of crucibles and consequently commands a higher price than other Austrian graphites. The principal use, however, is for foundry facings. The Celli district, in southern Styria, produced a small quantity of graphite between 1902 and 1907.

The Bohemian graphite was formerly used largely for pencils, and considerable quantities were exported to this country before the war, although the bulk of the exports went to Germany. Mexican graphite has now replaced the Bohemian material and will probably continue to do so. The principal value of the Austrian graphite appears to be for use in foundry facings, paints, and similar articles for which a high-grade product is not required.

The Czecho-Slovak and Austrian deposits will have to meet the competition of imported amorphous graphite from Chosen and possibly from Mexico, but most of the deposits appear to be well situated for cheap mining and, especially where a high-grade product is

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not required, should be able to supply the demand in central Europe for foundry graphite and possibly in part for the cheaper grades of lubricants. Graphite for crucible use will necessarily be imported. The nearness of the Czecho-Slovak and Austrian deposits to important manufacturing centers will always be a favorable factor.

The following are the most important papers dealing with the Czecho-Slovak and Austrian deposits:

GENERAL.

CIRKEL, F., Graphite, Canada Dept. Mines, Ottawa, pp. 65–70, 1907.
DAMMER, B., and TIETZE, O., Die nutzbaren Mineralien, vol. 1, pp. 63–65, 1913.
DE LAUNAY, L., Gites minéraux et métallifères, vol. 1, p. 388, 1913.
DONATH, E., Der Graphit, p. 36, Leipzig, 1904.
STUTZER, O., Die wichtigsten Lagerstätten der Nicht-Erze, vol. 1, pp. 17–41, 1911.
WEINSCHENK, E., Ueber einige Graphitlagerstätten: Zeitschr. prakt. Geologie, 1897, pp. 290–293.

BOHEMIA.

BILHARZ, O., Das Vorkommen von Graphit in Böhmen: Zeitschr. prakt. Geologie, 1904, pp. 324–326.
BREITSCHOPF, J., Das Graphitvorkommen im südlichen Böhmen: Oesterr. Zeitschr. Berg- und Hüttenwesen, vol. 58, pp. 131–136, 153–155, 167–169, 1910.

MORAVIA.

KRETSCHMER, F., Die Graphitablagerung bei Mährisch-Altstadt-Goldenstein: K.-k. Geol. Reichsanstalt Jahrb., vol. 46, pp. 21–56, 1897.
—— Die nutzbaren Minerallagerstätten der archäischen und devonischen Inseln Westmährens: K.-k. geol. Reichsanstalt Jahrb., vol. 52, pp. 353–370, 1902.
—— Die Entstehung der Graphitlagerstätten; Oesterr. Zeitschr. Berg- und Huttenwesen, vol. 50, p. 456, 1902.
STUR, D., Vorkomnisse von Graphit bei Pistau: K.-k. geol. Reichsanstalt Verh., 1872, p. 208.
TIETZE, E., Ueber das Graphitvorkommen bei Kunstadt in Mähren: K.-k. geol. Reichsanstalt Verh., 1873, pp. 38–40.

LOWER AUSTRIA.

SIGMUND, A., Die Minerale Niederösterreichs, pp. 14–16, Vienna, 1909.
TERTSCH, H., Graphit im Dunkelsteiner Wald: Min. pet. Mitt., vol. 26, 22 pp. 505–506, 1908.
VERGANI, E., Einiges über Grafit: Oesterr. Zeitschr. Berg- u. Huttenwesen, 1875, p. 325.

STYRIA.

AIGNER, A., Die Mineralschätze der Steiermark., pp. 154–157, Vienna, 1907.
ANDRÉE, T., Graphite mining in Austria and Bavaria: Iron and Steel Inst. Jour., vol. 2, pp. 738–740, 1890.
PAUL, K., Das Graphitvorkommen im Paltenthale vei Rottenman in Steiermark: K.-k. geol. Reichsanstalt Verh., 1872, pp. 169–172.
VON JOHN, C., Ueber steierische Graphite: K.-k. geol. Reichsanstalt Verh., 1892, pp. 413–418.
WOLF, H., Ueber den steierischen Graphit: K.-k. geol. Reichsanstalt Verh., 1871, pp. 115–117.

FRANCE.

The only producing deposit of graphite in France is in the Department of Hautes Alpes, not far from the Italian frontier. The graphite is amorphous and the deposit is geologically similar to the Italian deposits. The production, though small, has shown a steady increase in recent years.

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As the metallurgic industry of France is likely to grow, it will require a considerable supply of both crucible and foundry graphite. The crucible graphite will probably be supplied from Madagascar, and the foundry graphite also must be imported, as it does not seem probable that the Hautes Alpes deposit is capable of meeting the demand. The most convenient source of amorphous graphite for France appears to be Italy; possibly Czecho-Slovakia and Austria are also sources of supply, and the poorer grades of the Madagascar graphite, though not suitable for crucible use, are likewise available.

There are undeveloped graphite deposits in the departments of Arriège and Rhone.

GERMANY.

Germany possesses only one graphite region of importance, the Passau district in eastern Bavaria, close to the Austrian frontier. The graphite is of the flake variety and occurs in lenses in gneiss, carrying normally 20 to 25 per cent of graphite. These lenses are from 10 to 20 meters thick and are probably workable to a depth of 70 meters, owing to deep weathering. The deposits have been mined in a small way for centuries, but only since 1909 have modern mining methods been introduced. The deposits are favorably situated with respect to the supply of the famous Klingenberg clay for manufacture of crucibles, and the first graphite crucibles were manufactured in Passau. Some years prior to the war, however, Ceylon graphite had largely replaced the Bavarian graphite for crucibles and the local graphite was used chiefly for lubricants and foundry facings. The methods of mining and milling were antiquated and wasteful.

After the war began crucibles were perforce made with Bavarian graphite, and it is probable that in future improved methods of mining and milling will allow a larger use of the material than formerly; thus Germany may remain to a certain extent independent of foreign sources. Amorphous graphite can probably most readily be supplied to Germany from Czecho-Slovakia. Graphite, probably of the amorphous variety, occurs at Friedrichroda, near Gotha, but is not mined.

In 1918 old graphite mines at Tirschenreuth, in northeastern Bavaria near the Bohemian frontier, which had been idle since about 1860, were reopened.[1]

During the war there has been a shortage of graphite in Germany in spite of the output of the Bavarian, Bohemian, and Austrian mines. Numerous substitutes were used for foundry facings, and graphite was recovered from old crucibles by means of hydrofluoric acid.

The following publications contain more detailed descriptions of the German graphite deposits:

Cirkel, F., Graphite, Canada Dept. Mines, Ottawa, 1907.
Dammer, B., and Tietze, O., Die nutzbaren Mineralien, vol. 1, 1913.
Stutzer, O., Die wichtigsten Lagerstätten der Nicht-Erze, vol. 1, 1911.
Weinschenk, E., Die Graphitlagerstätten des bayerisch-böhmischen Grenzgebirges, Munich, 1897.
——— Ueber einige Graphitlagerstätten: Zeitschr. prakt. Geologie, 1907, pp. 286-290.

[1] Zeitschr. angew. Chemie, vol. 31, p. 210, 1918.

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ITALY.

The Italian deposits occur on the east flank of the Alps near Pinerolo, Province of Turin; in the Ligurian Mountains in the Bormida Valley, province of Genoa; and in the Province of Cuneo.

The graphite is amorphous and in places grades into the anthracite from which it was metamorphosed. It is apparently similar to the Austrian graphite and is used for foundry facings and lubricants. The beds attain a maximum thickness of 3 meters.

So far as known Italy has no supplies of clay suitable for the manufacture of crucibles and hence must depend on crucibles imported from France, Germany, or England, or both clay and crucible graphite must be imported. On the other hand, the production of amorphous graphite is in excess of local needs and formerly went chiefly to Germany, now to England and France. Unless Italian metallurgic industries should expand greatly there will be, at present rates of production, a considerable surplus available for export. Competition from Madagascar and Chosen can probably be met successfully owing to cheaper freights.

The following publications contain more detailed information on the Italian graphite deposits:

Novarse, V., I giacimenti di grafite delle Alpi Cozie: R. com. geol. Italia Boll., vol. 29, pp. 4–36, 1898. English abstract in Mineral Industry for 1900, vol. 9, p. 380, 1901.

Rivista del Servizio minerario, annual reports, 1881–1915.

Stutzer, O., Die wichtigsten Lagerstätten der Nicht-Erze, vol. 1, pp. 43–45, 1911.

NORWAY.

The production of graphite in Norway has hitherto been insignificant. According to recent reports, however, preparations are being made to work deposits in the Skaland district, northern Norway, on a large scale.[1] Apparently these deposits may be expected to furnish Norwegian requirements and allow a surplus for export.

PORTUGAL.

No graphite is produced in Portugal, and as it is not an important manufacturing country the demand is probably small. The deposits of the Almonaster district, in Spain, have been found to extend into the Contienda de Maura, a small area of disputed territory along the frontier, and in all probability enter Portugal. No developments are known, however.

RUMANIA.

Notices in the German technical press during the winter and spring of 1918 contained jubilant references to the discovery and exploration of immense graphite deposits in Rumania.[2] These deposits lie on the southern slope of the Carpathians at Baia de Fier and in the Oltetz Valley in western Rumania, apparently not far from the former Hungarian frontier. An area of 10,000 hectares was leased from the Rumanian Government for a period of 75 years, the product to be

[1] Carson, H. E., Norwegian graphite industry: Commerce Repts., May 23, 1918, p. 727.

[2] Zeitschr. angew. Chemie, vol. 31, p. 76, Feb. 15, 1918. Min. Jour. (London), July 6, 1918, quoting from Metall und Erz. Soc. Chem. Ind. Jour., vol. 37, p. 222 R, 1918, quoting from Chem. Zeitung, Apr. 10, 1918; p. 342 R, quoting from Metall und Erz, June 8, 1918.

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divided between Germany and Austria. Development work began in February, 1918.

RUSSIA.

Russia, particularly Asiatic Russia, possesses large reserves of graphite, but so far as data are available the production has been insignificant. The famous Alibert mine, near Irkutsk, in eastern Siberia, formerly produced a considerable quantity of pencil graphite, and this graphite has also been used to a small extent in the manufacture of crucibles. The other important deposits, those of Yenisei River in eastern Siberia [1] and those in the northern part of the Caucasus Province, probably consist of amorphous graphite. Some work was done on the Yenisei deposits in 1908 and 1909.[2] In the extreme eastern cape of Siberia there are graphite deposits similar to those of the Nome Peninsula, Alaska. The availability of the Russian deposits depends on the possible future development of Russia as a manufacturing country, for, unless the deposits should prove of exceptionally high grade, difficulties of transportation would reduce their availability for foreign use.

At the outbreak of the war the Morgan Crucible Co. established a crucible factory in Russia, and a large quantity of Ceylon graphite was imported. It is not known whether the clay was also imported or whether suitable local supplies were obtained.

The only deposit in European Russia concerning which any information is available is that of the Dzimarsk district, in the Caucasus.[3] Here graphite, presumably amorphous, occurs in large beds or lenses with an average thickness of 1 meter and a known extension of 1,500 meters. The carbon content ranges from 30 to 60 per cent.

Other occurrences are as follows: [4]

Pudosch district, near Onegasec, Olenetz government; Jelantschik district. southern Ural Mountains, granite boulders containing high-grade crystalline graphite; Zytomierc district, near Mecherzynce, Volhynia; near Mariupol, Jekaterinslav district, Ukraine, with a reported production of 2,000 tons (in 1913)[5]; Kumi Maggi, on the north shore of Lagoda Lake, Finland; Ekaterinburg; Miask; and Slatust. Graphite for foundry facings was recently mined at Boevsky, in the Ural Mountains.[6]

SPAIN.

Spain's recent production of graphite began in 1915 with an output of 33 metric tons, which increased to 1,240 tons in 1916, and gives promise of considerable future development. The principal district is near Almonaster, in Huelva Province.[7] The graphite is of the flake variety and occurs in graphitic schists. The portion now being developed is a belt 10 miles long and half a mile wide in which lenses

[1] Helmhacker, R., Graphitvorkommen in Russland: Berg. u. Huttenm. Zeitung, vol. 55, pp. 30-31, 1896. Sci. Am. vol. 115, p. 573, 1916. Min. and Sci. Press, July 24, 1915.
[2] Min. and Eng. World, p. 480, Sept. 9, 1911.
[3] Stutzer, O., Die wichtigsten Lagerstatten der Nicht-Erze, vol. 1, pp. 49-50, 1911. Dammer, B., and Tietze, O., Die nutzbaren Mineralien, p. 68, 1913.
[4] Russian Year Book, 1913. See also Stutzer, op. cit., and Dammer and Tietze, op. cit.
[5] Commerce Repts., Mar. 21, 1918, p. 1086.
[6] Board of Trade Jour. (London), Feb. 8, 1917, p. 428.
[7] Gracey, W. T., Commerce Repts., Feb. 12, 1918. Heriot, E. M., Mining in Spain: Min. Mag., vol. 19, p. 133, 1918. Trillo-Figueroa, A. C., Grafitos de la provincia de Huelva: Revista minera, vol. 69, pp. 215-217, 1918.

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containing 10 to 20 per cent of graphite are mined. The graphite schists, however, are known to extend from Alojao to Aroche and occur also in the Contienda de Maura, a disputed area between Spain and Portugal.

Other occurrences are as follows:[1]

Ijualija district, Sierra de Ronda, Malaga Province, amorphous; Mirabella district, near Ronda, Malaga Province, crystalline; between 1750 and 1800 this district produced 9,476 tons, but the deposit is apparently exhausted. Labour and Barbarissa Mountains, Spanish Pyrenees, Santander Province, reported small production prior to 1911.

With future development of the local iron industry the Spanish graphite deposits will probably become more important. The present production appears to be largely the result of Spain's comparative isolation during the war. Prior to the war Spain's requirements both for crucibles and graphite were supplied from Germany.

SWEDEN.

The Norberg deposit [2] in central Sweden appears capable of furnishing graphite suitable for crucible use. The annual production for the last few years has not exceeded 100 tons. In Lapland, near Vittangi, about 60 kilometers east of the Kiruna Railway, there are large undeveloped deposits of amorphous graphite.[3] These should become important as a source of graphite for foundry use as the Swedish iron industry develops.

During the war the manufacture of crucibles was begun in Sweden, but it is not known how far local material was employed.

SWITZERLAND.

A deposit of amorphous graphite at Iserables, Canton Wallis, Switzerland, near the French frontier, has been mined in a small way. The last recorded production was 3,000 tons in 1899, but it is possible that there were developments during the war. The material is similar in type to other Alpine graphite deposits and grades into anthracite. Crystalline graphite was formerly worked [4] at Roverado, Canton Graubunden, near the Italian frontier.

TURKEY.

Graphite is said to occur in the Dardanelles peninsula, but nothing is known as to the extent or value of the deposits.[5]

UNITED KINGDOM.

The famous Borrowdale deposit, in Cumberland, England, formerly furnished a very pure crystalline graphite which was used in the manuture of pencils. The deposit was discovered in 1564 and was worked

[1] Stutzer, O., op. cit., p. 53. Dammer, B., and Tietze, O., op. cit., p. 67.
[2] Lindroth, G. T., Grafitvyndigheterna inom Norbergs Bergslag: Geol. Foren. Stockholm Förh., Bd. 40, pp. 27-76, 1918.
[3] Stutzer, O., op. cit., p. 52.
[4] Stutzer, O., op. cit., p. 54. Dammer, B., and Tietze, O., op. cit., p. 66.
[5] Dammer, B., and Tietze, O., op. cit., p. 68.

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extensively between 1788 and 1833. The last production was made in 1876, and the deposit is supposed to be exhausted.

Near Cumnock, in Ayrshire, there is a bed of coal locally altered to amorphous graphite by an intrusion of dolerite. This deposit was worked on a small scale between 1750 and 1848. It was reopened for a short time in 1908, and 101 tons of graphite, used for foundry facings, was extracted.

A seam of graphite from 1 to 3 feet wide occurs near Invergarry, in Inverness-shire. A production of two tons was obtained from this seam in 1825 and it is considered that deposit may prove worthy of development.[1] Graphite is also reported from Montgomeryshire and Merionethshire.

As the iron and steel industry of England is of great magnitude, the country is a large consumer of graphite. The crystalline graphite required is imported from Ceylon and Madagascar, and the amorphous graphite from Chosen and Italy. Supplies of clay suitable for making crucibles are available.

ASIA.

CEYLON.

Until recently Ceylon was the largest producer of high-grade crucible graphite in the world. In 1913 the output of this island as measured by tons was 20 per cent of the world's production, but by value it amounted to 64 per cent. Lately the output has been surpassed in quantity though not in value by Madagascar. Bastin [2] has summarized the available descriptions of the Ceylon graphite deposits as follows:

The following account of the graphite deposits of Ceylon is condensed from a paper[3] published in 1911. Those desiring more complete information should consult the original paper and its accompanying bibliography.

The graphite deposits of Ceylon [see fig. 54] are of especial interest to Americans because most of the graphite used in this country comes from that island and because the United States has for many years been the largest consumer of the Ceylon material. Much has been printed in regard to these deposits, but it is widely scattered through publications in various languages which are not readily accessible to the American public. The writer has, therefore, summarized the more important facts which are on record, with apologies for any errors which may have crept in on account of his lack of personal knowledge of the island.

Although their existence was known in early times and mentioned in print as early as 1681, the graphite deposits of Ceylon were not exploited until some time between 1820 and 1830. Joseph Dixon is said to have imported a small quantity into the United States in 1829, but it was not until 1834 that the industry assumed any commercial importance. From that time to this, as a result of the growth of metallurgical industries and the resulting demand for refractory materials, the industry has developed rapidly, until at present graphite is subordinate in value only to tea and the products of the cocoanut palm among the exports from the island. * * *

From the early days of the industry up to 1901, Great Britain consumed more Ceylon graphite than any other country. Since 1901 the United States has assumed the first place, with Great Britain second until 1909, when Germany took second place. * * *

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[1] Strahan, A., and others. Special reports on the mineral resources of Great Britain: Geol. Survey Mem., vol. 5, pp. 25–27, 1916.

[2] Bastin, E. S., U. S. Geol. Survey Mineral Resources, 1913, pt. 2, pp. 234–238, 1914.

[3] Bastin, E. S., The graphite depositsof Ceylon; a review of present knowledge with a description of a similar graphite deposit near Dillon, Mont.: Econ. Geology, vol. 7, pp. 419–433, 1912; also U. S. Geol. Survey Mineral Resources for 1911, pt. 2, pp. 1094–1103, 1912.

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With the exception of a limited amount of graphite mining done on tea estates, the industry is in the hands of native Sinhalese. It has been estimated that the various processes of mining, sorting, "curing," packing, and shipping graphite, as well as the making of barrels in which it is exported, provide employment for about 50,000 men, women, and children.

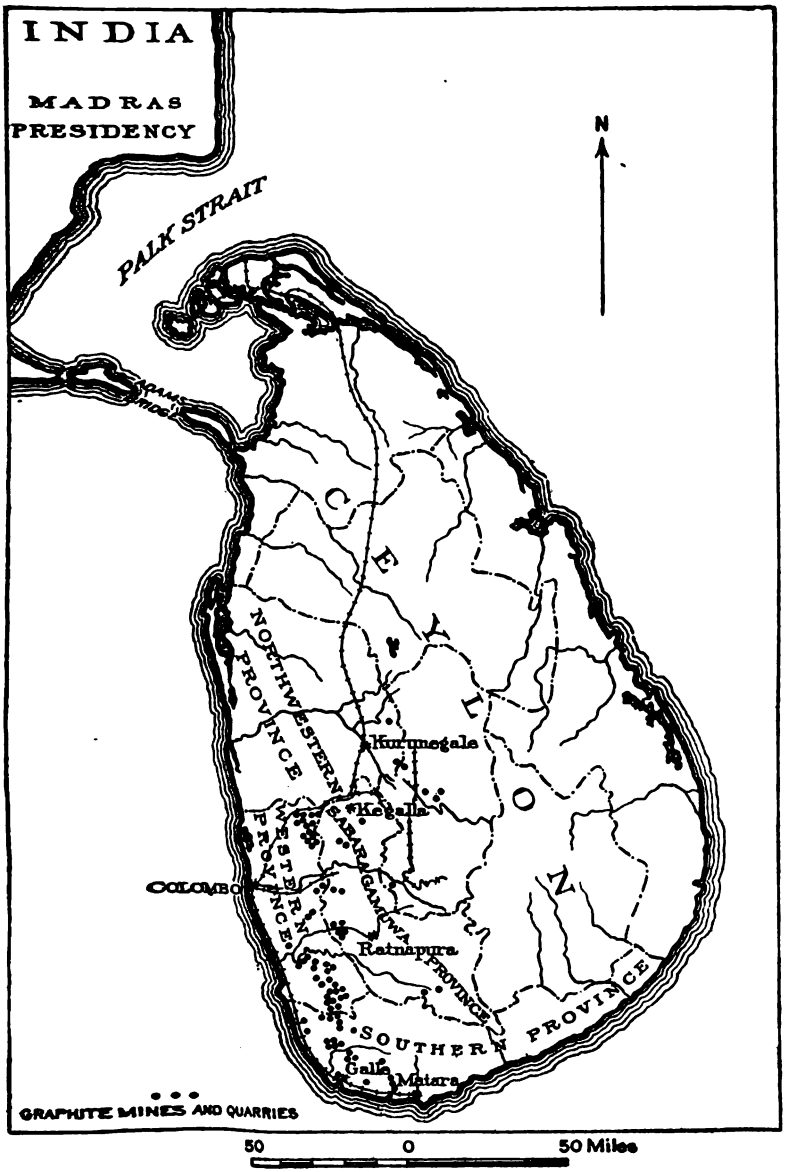

FIGURE 54.—Map showing location of Ceylon graphite deposits.

The island of Ceylon is just off the southern point of the peninsula of British India, the channel between being nowhere deep enough for the passage of large ships. The island is more or less pear-shaped in form, and has a length from north to south of about 275 miles and a maximum width of about 135 miles. A railroad extends the

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entire length of the island, with branches into the central interior. Colombo, the capital and principal seaport, is on the western coast, and is the port from which nearly all of the graphite is shipped. A small quantity is shipped from Galle.

The island of Ceylon may be divided into two natural divisions—a mountainous region of crystalline rocks, which forms the southwestern part of the island, and a lowland area made up of coral limestones and marine sands of much later origin to the north and east. In the mountainous region there are 10 peaks which rise to elevations of over 7,000 feet, the highest being 8,296 feet. This region covers about one-fifth of the area of the island. The principal mines are in the south-central and southwestern parts of the island, and all are within the mountainous region.

The most abundant rocks of the mountainous crystalline area are gneisses of both light and dark varieties. Intimately interbanded with the commoner types of gneiss in bands varying from a few inches to hundreds of yards in width are crystalline limestones, many of which are dolomitic. The origin of the gneisses is not certainly known, but the presence of beds of crystalline limestone will be regarded by most geologists as proof that a part of them at least are metamorphosed sediments. Others are probably altered igneous rocks.

The groundmass of gneissic rocks has been intruded by several types of massive igneous rocks, among which granite pegmatites are conspicuous. The graphite is present locally in small amounts, disseminated in the crystalline limestones and some of the gneisses. The commercially important deposits, however, are all veinlike in character and were deposited along fracture planes in the rocks. They were thus formed distinctly later than the rocks which they traverse. In most of the graphite districts the main veins parallel the foliation planes of the gneisses, thus striking northwest and southeast. In the Kurnegale district, on the other hand, the principal veins strike northeast and southwest, parallel to a system of joint fractures. In any pit or series of pits there is usually a single main vein or several parallel veins following one of these directions of fracturing and sending off minor veins or stringers along the less prominent set of fractures. In some places the extent of the veins along their trend is so slight that they may be more correctly described as lenses. In other places veins of considerable width may contract to mere seams, only to widen again when followed farther. The width of the vein varies from less than an eighth of an inch to several feet, and some as narrow as 2 or 3 inches are worked. The walls are usually sharply defined, and the bordering rock is not impregnated with graphite to a distance of more than half an inch from the veins.

In small veins the graphite usually forms an aggregate of parallel platy needles set at right angles to the vein wall. In the larger veins most of the graphite shows a coarse platy structure, though the needlelike structures may be developed in a band from a few millimeters to 2 or 3 centimeters across next the walls or next masses of wall rocks inclosed in the vein. The needlelike aggregates are in high favor commercially, because of their highly fibrous structure and are known as "needle lump." Spherulitic aggregates of graphite plates are of occasional occurrence.

Usually the veins consist almost entirely of graphite, but sometimes other minerals occur in important amounts. Pyrite is almost always present either disseminated between the individual flakes or needles or concentrated in a more or less definite band in the central portion of the vein. Occasionally a pyrite crystal is penetrated by graphite flakes. Quartz, usually milky, often forms a part of the vein, sometimes occurring as a central band. In a few places rosettes of graphite flakes occur in the quartz, and in other places quartz grains lie between flakes of graphite. Quartz and pyrite are the only accessory minerals which are nearly always present, but occasional minerals are biotite, orthoclase feldspar, pyroxene (usually augite), apatite, allanite, and rutile. The last is sometimes developed along cleavage planes in the graphite crystals. In one mine a remarkable cavity or "vug" was encountered, which was about 15 feet high, more than a yard wide, and oval in section. Its walls were lined with flaky graphite, and similar material filled its lower portion. In some of the graphite veins slight movements subsequent to their formation have bent the graphite flakes or crushed them to an earthy mass and developed slickensided fracture surfaces.

The graphite is mined either from open pits or through vertical shafts connecting with underground workings. The majority of mines are not deeper than 100 feet, though a few go as deep as 400 or 500 feet. On account of the heavy rainfall, water is one of the chief obstacles in deep mining. In a few mines steam pumps and hoists are employed, but as a rule the mining methods are still crude, the acme of mechanical ingenuity being reached in a windlass operated by five or six men for hoisting the graphite in a sort of tub. The workmen usually ascend and descend by means of rough wooden ladders, tied with jungle ropes and rendered exceedingly slippery by the graphite dust and water.

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The mineral as it comes from the pits may contain as much as 50 per cent of impurities, mostly in the form of quartz and wall rock. It is conveyed in bags to a dressing shed, where it is picked over and the impurities reduced to 5 or 10 per cent. It is then packed in barrels for transportation to Colombo or Galle. At these ports it is unpacked and submitted to further treatment, known as "curing." The graphite merchants have fenced yards or "compounds" for the final preparation of the graphite for the market. In the methods of "curing" there is some diversity, but the first step is usually to set aside the large lumps and to pass the remainder through stationary screens of several different sizes of mesh. The large lumps and the screened pieces are then broken with small hatchets by Sinhalese women to remove the coarser impurities, such as quartz, and are then rubbed up by hand on a piece of wet burlap and finally on a piece of screening to give them a polish. Finally, various grades coming from several mines or differing in size or texture are blended to meet the requirements of purchasers, a process requiring skill and long experience.

The poorer material is usually beaten to a powder with wooden mauls or with beaters shaped like a rolling pin, and is then sorted into different grades. In some establishments the impure grades are washed in a tub or pit. In this process the mineral is placed in saucer-shaped baskets, and by a circular "panning" motion of the immersed baskets the graphite particles are thrown off into the pit, while the heavier impurities, especially pyrite, remain behind. To separate the very fine material, the powdered graphite is placed in a basket with somewhat the shape of a large dustpan. The contents of the basket are thrown into the air, and the heavier particles fall back into the basket, while the finer material is blown forward and falls on the floor.

The graphite-mining industry in Ceylon was in a very depressed condition during 1914, because of shortage of labor and of the unusually heavy rains, which interfered with mining operations. This depression was aggravated by the embargo imposed in October, 1914, on the exportation of graphite to countries other than those of the allies. After the modification of the restrictions on exports to the United States, about the middle of 1915, and because of the greatly increased demand for graphite for crucibles to be used in the manufacture of munitions, most of the mines resumed operations.

The years 1916 and 1917 were years of great prosperity for the Ceylon graphite industry. The demand for Ceylon graphite by American crucible makers increased greatly, and the best grades of lump, which prior to the war did not bring more than $150 a long ton, sold as high as $500 a ton. The competition of the increasing output of Madagascar was scarcely felt, as the Madagascar graphite went chiefly to the British and French markets, whereas America took most of the Ceylon exports, 75 per cent in 1916 and 81 per cent in 1917. The principal drawbacks were the increased cost of mining, due to working at greater depth, and the high freight rates, which spoiled the market for the lower grades, such as dust and flying dust.

The freight rate in effect on graphite shipped from Colombo to New York in 1916 was $34.80 a ton, plus a war surcharge of 50 per cent on shipments by way of Cape of Good Hope. In addition to this there was a supplemental charge of 10 per cent on the total of the gross freight and surcharge.[1]

Another important factor affecting the cost of Ceylon graphite was the rise in price of casks and hoop iron. Barrels advanced in price from $1 in 1914 to $2.50 in 1916, and hoop iron went up in price from $50 to approximately $150 a ton.

The former export duty on graphite was $1.62 a ton; this was changed on July 22, 1916, to 3 per cent ad valorem, thus increasing the cost to the consumer.

[1] Commerce Repts., Sept. 4, 1916, p. 42.

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Toward the end of 1917 the American demand fell off and the prices declined somewhat, resulting in a decrease in output.

The graphite mining is largely in the hands of native Ceylonese, the majority of owners being men of small means with labor forces not usually numbering more than 20. Such owners must rely on an immediate sale of their graphite, and any marked fluctuations in the market will cause them to shut down or open up their mines. Thus on June 30, 1917, when the market was good, 1,288 mines, employing 19,912 men, were in operation, as compared with 764 mines at the end of the year, employing 15,379 men. The small mines are obviously the first to be shut down in case of market depressions.[1]

The American import restrictions put into force in the spring of 1918 proved a severe blow to the Ceylon graphite industry. The price of lump graphite fell to less than half the former price and lower grades were almost unsalable. Exports in 1918 were less than in any year during the preceding decade except 1914, and in addition large stocks accumulated for which there was little demand after the armistice.

Prices early in 1919 were reported as follows:[2] Lump, $115 to $225 a long ton; chip, $65 to $150; dust, $20 to $100; and flying dust, $13.

Costs of mining rose greatly during the war, but it is said that with the installation of improved machinery and the development of the mines to greater depths an annual production of 30,000 tons can be maintained for many years.[1]

The following table shows exports from Ceylon for 1913–1918. In addition to the graphite directly imported by the United States a portion of that sent to Great Britain during 1914 to 1918 was consumed in this country.

Graphite exported from Ceylon, 1913–1918, in short tons.

Country.	1913[a]	1914[a]	1915[b]	1916[b]	1917[b]	1918[b]
United States	14,461	7,759	15,480	28,494	24,601	9,418
Germany	6,178	3,526	.....	.....	.....	.....
United Kingdom	5,348	2,952	6,036	6,189	5,152	7,152
Belgium	1,969	969	.....	.....	.....	.....
British India	27	65	58	132	162	339
Australia	225	356	293	312	265	329
Austria	.....	39	.....	.....	.....	.....
France	122	139	.....	.....	.....	.....
Italy	21	6	.....	.....	.....	.....
Holland	8	30	.....	.....	.....	.....
Japan	107	69	18	.....	.....	68
Russia	.....	4	2,238	2,615	112	.....
Other countries	74	24	.....	1	1	1
	28,540	15,938	24,123	37,743	30,293	17,307

[a] Ceylon Blue Book. [b] Ceylon Chamber of Commerce Repts.

CHOSEN (KOREA).

Chosen graphite was formerly used quite extensively in this country, but in 1918 very little was imported on account of import restrictions.

[1] Commerce Repts., Aug. 9, 1918, p. 535. [2] Idem, Mar. 25, 1919, p. 474.

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The graphite industry of Chosen is of recent date, the first exports having been made in 1903, and it was not until 1907 that exports reached 1,000 tons a year. The production appears to have increased steadily, except for a slight decrease in 1915, due to high freight rates, until 1917, when there was a sharp decline in production caused by the partial loss of the American market owing to Mexcian competition. It is estimated that out of a production of 6,500 long tons in 1917, only 4,500 tons was exported. Prices, which in 1916 were more than double those of 1913, had fallen back to the pre-war level. In the spring of 1918 Chosen graphite was excluded from America by the import embargo and, although statistics are not available, it is probable that production declined heavily as the Japanese demand does not exceed 3,000 tons annually, even under war conditions.[1]

Most of the Chosen graphite is of the amorphous variety and is used principally for foundry facings. It comes chiefly from the central and eastern part of the kingdom and is shipped from the port of Fusan. The graphite occurs as beds and irregular lenses. At one of the mining localities in the Kyeng-Sang district three seams of graphite with maximum widths of 78, 18, and 48 feet have been mined.[2]

There is also a small production of crystalline graphite in the northern part of the country. This material is said to occur in thin flakes similar to the crystalline graphite of Alabama.[3] So far as known very little of this material has come on the American market.

JAPAN.

Japan produces a small quantity of graphite, apparently both amorphous and crystalline. Little information is available regarding the deposits. The graphite imported into this country from Japan is probably mined in Chosen.

INDIA.

Formerly graphite similar to that of Ceylon was mined in the State of Travancore, in southern India, but with increasing depth the mines became unprofitable, and production, which had ranged from 2,000 to more than 4,000 tons a year, ceased in 1911. In recent years some graphite has been produced in Rajputana and Kalahandi. Undeveloped deposits occur in the Ruby Mines district of Burma.

CHINA.

Graphite is reported from many localities in China, but none of the deposits have been developed.

MALAY STATES.

Graphite deposits of considerable extent have lately been reported in the Malay States but nothing definite is known with regard to them.

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[1] Soc. Chem. Ind. Jour., vol. 37, p. 329 R, Aug. 31, 1918.
[2] Mining Industry in Japan, p. 51, Tokyo, Imperial Bureau of Mines, 1915.
[3] Clements, J. M., personal communication, Feb. 27, 1919.

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AFRICA.

MADAGASCAR.

The graphite industry in Madagascar has made remarkable progress in recent years. The industry began in 1907 with a production of 8 metric tons, and the output in 1917 amounted to 35,000 metric tons, exceeding even the Ceylon exports. The graphite is of the flake variety and is very similar in appearance to the best American flake graphite. It occurs in graphitic schist and gneiss throughout the area of older crystalline rocks, which occupy over two-thirds of the surface of the island.

The following description of the Madagascar deposits is reprinted from the Geological Survey report on graphite for 1913:[1]

An interesting account by P. Contanciel of the occurrence of graphite in Madagascar was published in a French journal[2] in 1912. The parts likely to be of interest to Americans are summarized below. For exact locations, maps, and diagrams, the reader is referred to the original article.

The known occurrences of graphite in Madagascar are confined to the area of ancient crystalline rocks that forms the eastern half of the island. This crystalline tract is in turn divisible into a high plateau region and a lowland tract. Graphite occurs in each but in a somewhat different manner.

GRAPHITE IN THE HIGH PLATEAU TRACT.

The climate of the plateau tract is much less humid than that of the lowlands and vegetation is less prolific. The plateau is in many places separated from the lowlands lying east of it by a steep escarpment whose heavily forested slope extracts much moisture from the prevailing easterly winds.

Because of the climatic features rock exposures are much more abundant than in the lowlands, and there are no deep deposits of "laterite," that is, soil resulting from prolonged rock decay. The graphite deposits are, therefore, strictly bedrock deposits. In the commonest type the graphite is a constituent of a graphitic schist and forms flakes lying between grains of quartz or altered feldspar. Biotite or black mica is sometimes present, but in general is not abundant in the highly graphitic schists. The graphitic schists discovered up to 1912 occur in three principal bands, two of which pass near Tananarivo, the capital of the island. Most of the deposits now known have been covered by claims, but development had at the time this article was written not advanced beyond the "prospect" stage. Their exploitation would involve the crushing of the rock and the separation of the graphite by washing or other means from the feldspar, quartz, and mica with which it is intergrown.

A second mode of occurrence of graphite in the plateau tract is in so-called flat veins (filons couchés). Their exact character is not quite clear from M. Contanciel's descriptions. He states that they lie parallel to the foliation of the schists, and that some of them attain a thickness of as much as 20 meters.

Their graphite content is higher than that of the ordinary graphitic schists, and may reach 30 per cent, though seldom more. They have been the object of serious exploitation at several places, the excavations commonly being open pits, though in a few places shafts and galleries have been driven. The open pits seldom exceed 25 meters in depth and are all, therefore, in more or less decomposed material which is easily excavated.

The Tsarazafy concession northwest of Tananarivo is an example of a property worked by underground methods. The method of concentration employed at the Tsarazafy concession is described as follows: The crude material, which seldom contains more than 30 per cent of graphite, is first washed in tubs by women laborers along the river bank. By this washing the graphite concentration is raised to about 50 per cent, much being lost in the process. The material is next spread on hearths heated by brush fires, to dry, and then fed to a series of screens with round openings 3, 2, and 1 millimeters in diameter. The oversize from the 3-millimeter screen is sent to crushing rolls and then again passed over the screens. The sized product from the screens goes to winnowing machines, somewhat similar to those used in

[1] Bastin, E. S., U. S. Geol. Survey Mineral Resources, 1913, pt. 2, pp. 242–244, 1914.
[2] Contanciel, P., Note sur les graphites de Madagascar: Soc. Indust. min. Bull., November, 1912, pp. 505–530.

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vanning corn. The products of these machines are tailings that are discarded, middlings that are re-treated, and two sizes of graphite concentrate (1 to 2 millimeters

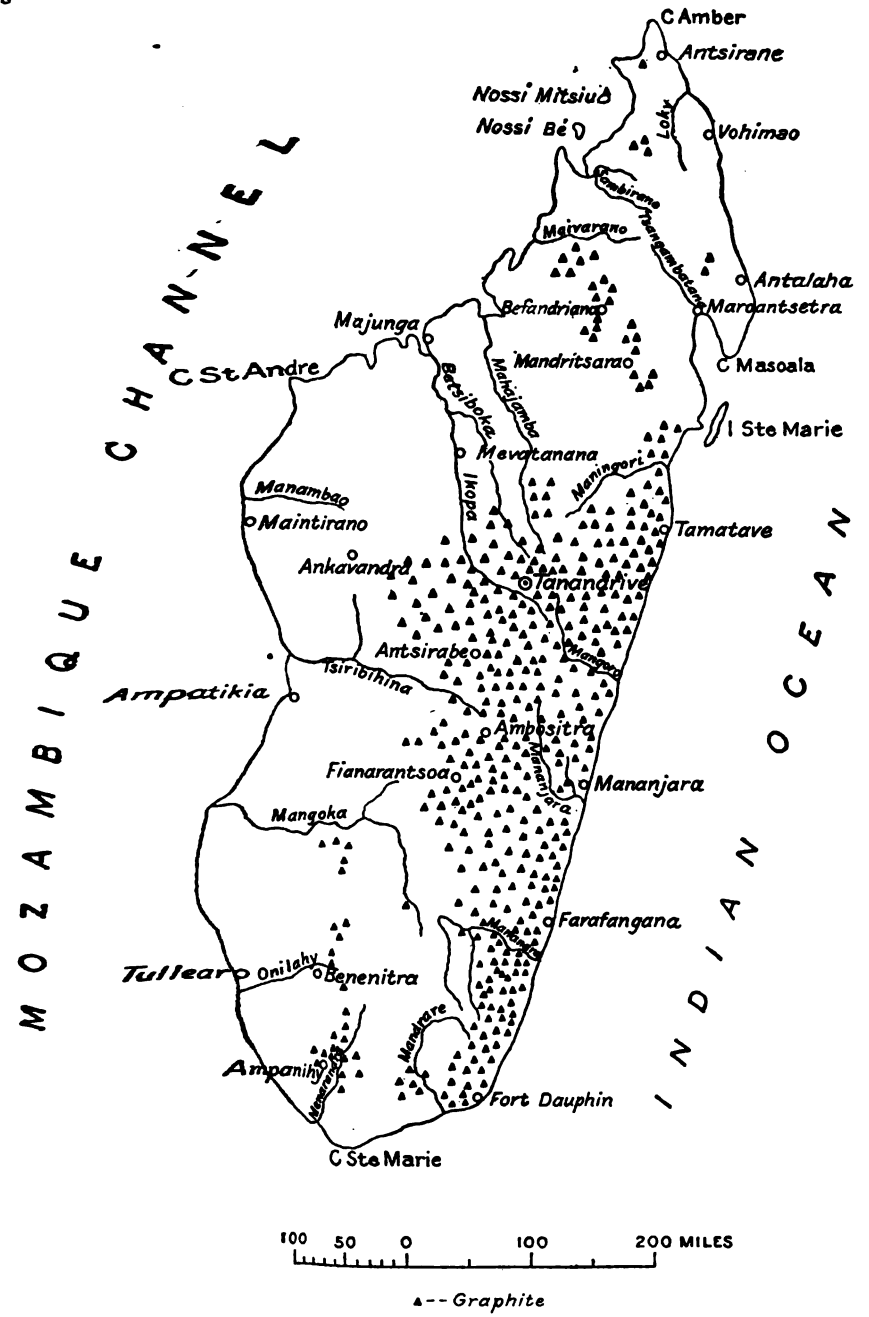

FIGURE 55.—Map showing location of Madagascar graphite deposits.

and 2 to 3 millimeters). The vanning is not very efficacious in separating the fine rock dust and much of it is eliminated by further screening. The final product,

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averaging about 80 per cent graphite, is only 5 to 10 per cent by weight of the rock mined. After sacking it is ready for shipment. Electric power for the mill is supplied from a power plant at a falls 2 kilometers distant. The cost of mining and milling by this process is about 90 francs ($17.37) per metric ton of concentrate produced.

The native process is still simpler, and at the Louys mine, at Isahâ, is carried on as follows: A laborer breaks the lumps of crude material with a mallet or a club and throws the material into a cubical tub 0.6 meter in diameter. A current of water enters at one side of the tub and leaves at the other, and the same laborer agitates the material in the tub with a spade. The overflow from the tub goes into a slightly inclined wooden trough 4 meters long, 0.3 meter wide, and 0.3 meter deep, whose lower end is half closed by a board 0.15 meter high. The agitation in the tub tends to float off the slime, while the sand and most of the graphite remain behind. Whatever graphite floats off is caught in the trough. The washed mixture of sand and graphite is dried in the sun on floors and then passed to screens of 4, 8, 12, and 16 meshes per centimeter. After the screening the several sizes are sacked. The product averages about 70 per cent graphite and forms about 2 per cent by weight of the rock as mined. The cost of mining and milling is about 100 francs ($19.30) per metric ton of concentrate produced.

* * * * * * *

GRAPHITE IN THE LOWLAND TRACTS.

The lowland tract, east of the plateau tract, is characterized by great humidity and by prolific vegetation, which completely masks the bedrock. The soil resulting from rock decay ("laterite") is deep and in it the graphite occurs. The original rock before decay was probably similar to the graphitic schist of the plateau tract. The process of rock decay has served to increase somewhat the percentage of graphite by removing some of the more soluble constituents of the rock, and has yielded an incoherent and easily excavated material which requires no crushing. The greater ease and cheapness with which the graphite deposits of the lowlands can be worked, as compared with those of the plateau, is counterbalanced to some extent by transportation difficulties. Real roads are practically lacking, and if constructed are almost impossible to maintain. It is hard to conceive how difficult it is for the natives themselves to cover even small distances along the paths that are pompously called "roads," and all transportation in our day, at least, must be on the backs of men. Because obscured by vegetation, the deposits are less easily located and followed by the prospector than in the plateau tract.

According to another description[1] the rock weathering in the plateau country, where most of the productive mines are situated, extends to depths of 150 to 200 feet. The graphite forms irregular lenticular deposits, and both flake graphite and the fibrous variety are present.

A recent article by Shelley[2] gives more detail concerning mining methods and costs, and this portion of the article is summarized below.

The graphite generally occurs in partly decomposed gneiss, associated with soft micaceous or chloritic schist. The bulk of the graphite is in the form of thin flakes from one-eighth inch in diameter down to the finest dust. Some very pure lump and fibrous graphite is found, but seldom in sufficient quantity to render separate treatment profitable. As dug out and taken to the dressing floors the ore contains 60 per cent of graphite. [This is a far higher tenor than is given in other descriptions.] Of this only about one-third is recovered by present methods. Of the recovered portion 60 per cent, with a carbon content reported to be from 90 to 96 per cent, is suitable for the manufacture of crucibles, the remainder being fine dust. Some deposits are at present unworkable owing to their high percentage of iron

[1] Bawden, E. R., Some observations on the graphite deposits of Madagascar and Africa: Chem., Met., and Min. Soc. South Africa Jour., vol. 13, p. 258, 1912.
[2] Shelley, J. W., Graphite in Madagascar: Min. Mag., vol. 14, pp. 324-330, 1916.

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oxide and mica. The deposits are usually worked by open cuts, except in a few places, where they are opened by drifts into the sides of the hills. After removing the overburden and intervening partings, the crude graphite is dug out by spades and removed in barrows and baskets to the sluices, which are at a lower level, close to the mine.

The sluices are rectangular wooden boxes, 36 inches square by 24 inches deep, let into the sloping ground on three sides. On the lower side there is a sliding door, which can be raised to permit the discharge of the débris. The boxes are kept filled to a depth of 8 inches. A steady stream of water, equal to about 8 gallons a minute, is led into each box, and the material is constantly stirred with a wooden paddle. In this way the fine sand, mud, and flake graphite are kept in suspension and flow over the lip of the box into a small trough with a 60-mesh screen nailed to the bottom. The muddy water and fine sand pass through the screen, while the flake is retained. The flake is pushed forward by the gentle waves produced by the paddle and is discharged into a small box. The washing process requires two operations, the one to separate the bulk of the coarse material and the other to separate the particles of fine quartz and feldspar and obtain a clean product. Each gang produces about 1 hundredweight a day. The waste contains a quantity of large flakes and chips. The washed graphite is dried in the open on mats.

The next processes are those of vanning and sifting and are performed by women. The vanning consists in tossing up the material so as to bring the dust and sand to the outside edge of an oblong wooden tray and tipping it over the side by a dextrous movement of the wrists. It is afterwards screened into three grades of 20, 40, and 60 mesh. Satisfactory material is credited to the worker at the rate of 10 centimes a kilogram (slightly less than 1 cent a pound). Rejected material is returned to undergo further treatment.

At a mine with an average yield of 25 metric tons a month, costs are about 225 francs a ton (2 cents a pound). Costs of transportation are estimated at 97.50 to 130.50 francs a ton, and shipping charges and freight to London from 71.50 to 92 francs. Other costs, including incidental expenses, stores, taxes, etc., are estimated at 30 francs a ton, and the total cost, c. i. f. London, between £17 and £19 a ton, (between 3.8 and 4.2 cents a pound, at normal exchange).

De Pritzbauer[1] in a recent article states that the graphite tenor of the ore in favorable places is 25 to 30 per cent, but that 10 per cent ore is considered workable. According to this article the average cost at the mines scarcely exceeds 100 francs a metric ton, but transport charges to Tamatave are between 350 and 400 francs.

According to Bonnefond,[2] if the base price of 600 francs a metric ton (5.25 cents a pound at normal exchange) for 90 per cent material f. o. b. Tamatave is maintained, the productive capacity of Madagascar is at least 50,000 tons a year. He estimates that there is 2,000,000 tons of merchantable graphite in sight, capable of being mined by open-cut methods, and an additional 7,000,000 to 8,000,000 tons, which can be exploited to a depth of 100 meters below the surface.

[1] De Pritzbauer, L., L'avenir de Madagascar: Chimie et industrie, vol. 1, pp. 679–680, 1918.
[2] Bonnefond, F., Les mines de Madagascar en 1918: Soc. ing. civils de France Bull. 7 and 8, pp. 366–367, 1919.

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After several years of exceptional prosperity the graphite industry in Madagascar is now suffering a setback consequent upon overproduction. During 1917 the production greatly exceeded the exports, and it is estimated that by February, 1918, stocks of about 15,000 tons had accumulated in the island, in addition to large quantities in Marseille, France. Graphite was exported only under license of the French Ministry of Armament. The principal purchaser was the Graphites Maskar, a subsidiary of the Morgan Crucible Co., of London. About half the exports in 1917 went to England and the remainder to Marseille, whence a part was reexported to America.

In 1917 the graphite industry gave employment to several thousand white men and about 200,000 natives, and 4,064 claims had been taken up. By the summer of 1918, however, production had nearly ceased. The import restrictions of the United States had excluded graphite from the American market, further imports into France were prohibited except by special license, and the Morgan Crucible Co., the principal buyer, had reduced its purchases to one-sixth of the former amount and had given notice that no more would be bought after July 1, 1919.[1] In May, 1919, stocks of Madagascar graphite at Marseille were reported to amount to 12,000 to 14,000 metric tons,[2] which together with the stocks in Madagascar, amounting to 25,000 metric tons in January, 1919, must be absorbed before mining can return to its former basis. In November, 1918, the Union des producteurs de graphite de Madagascar offered to furnish annually to the United States 15,000 to 20,000 metric tons of flake graphite at 600 francs a ton, f. o. b. Tamatave.

The Madagascar government has authorized the exportation to the United States during the first half of 1919 of 15,000 tons of graphite. It is doubtful, however, whether trade conditions in this country would allow the absorption of more than a small part of this.

The production in 1918 was 16,000 metric tons and during the first nine months of 1918 exports of graphite from Madagascar amounted to 15,014 metric tons, valued at $1,303,768.[3]

SOUTH AFRICA.

A small quantity of graphite is produced annually in the Transvaal.[4] The deposit now exploited is in the eastern portion of the Zoutpansberg district. It is in the form of a lens with an average thickness of 10 feet, and has been proved along the strike for a distance of 250 feet. The footwall is formed by decomposed pyroxenite and is overlain by schistose quartzite dipping 55° S. The pyroxenite incloses crystals and flakes of graphite and may be genetically related to the deposit. The greater part of the lens consists of amorphous or finely crystalline massive graphite, which is traversed by narrow veins of flake graphite. The amorphous graphite is fairly pure except near the hanging wall, where it is mixed with arenaceous matter. A series of representative samples assayed from 50 to 90 per cent carbon.

[1] Waites, T. P., Madagascar graphite production; Chem., Met., and Min. Soc. South Africa Jour., vol. 19, pp. 32–33, 1918. Carter, J. G., Madagascar graphite situation: Commerce Repts., Aug. 16, 1918, p. 630.
[2] Commerce Repts., June 23, 1917, p. 1535.
[3] Carter, J. G., Madagascar's trade for nine months: Commerce Repts., Apr. 19, 1919, p. 440.
[4] Wagner, P. A., Graphite in South Africa: South African Journal of Industries, February, 1918. Abstract in Mining Magazine, pp. 320–321, June, 1918.

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The graphite is shipped to Johannesburg and there made up into various graphite products for which there is a good local demand.

The paper cited above mentions other graphite deposits in Transvaal, Southwest Africa, Natal, and southern Rhodesia, none of which has yet proved worthy of development.

EAST AND CENTRAL AFRICA.

Graphitic schists of high graphite content and vein graphite are reported to occur at several places in the Nyasaland Protectorate,[1] British East Africa,[2] and German East Africa.[3]

PORTUGUESE EAST AFRICA AND BELGIAN KONGO.

The available descriptions of graphite in Portuguese East Africa [4] and the Belgian Kongo [5] indicate large reserves of high-grade graphite, but lack of cheap transportation facilities has hitherto prevented development.

AUSTRALIA AND NEW GUINEA.

Deposits of flake graphite of probable commercial importance occur in Eyre's Peninsula, in South Australia.[6] The graphite occurs in schists which are associated with quartzite and lime-silicate rocks and intruded by pegmatitic granite. The flake close to the surface carries much limonite and grit, and a clean product is not easily obtainable. At depths of 10 to 20 feet the flake is clean, and the prospects are considered favorable for the development of large bodies of workable ore. The most promising part of the region appears to be the Uley district, near Port Lincoln. Here rich streaks contain as much as 31 per cent of recoverable flake, and it is estimated that at least 7 per cent can be recovered over a large area. The estimated costs of mining and milling are given as 16 shillings a ton of ore, which, on a basis of 7 per cent recovery, would equal about 2½ cents a pound of graphite. In order to encourage graphite production, the State of South Australia has offered a bounty of £1 per ton on all graphite produced prior to June 30, 1919. Graphite deposits at Mount Bopple,[7] in Queensland, were formerly worked in a small way. The graphite is amorphous and is formed from coal beds graphitized by granitic intrusions.

Graphite occurs in New South Wales at Wilson's Downfall,[8] and a small quantity has been produced in recent years. In Western Australia deposits of flake graphite have been prospected in the Plantagenet district,[9] and at Munglinup, Eucla division, near the south

[1] Dunstan, W. R., Nyasaland protectorate, report on the results of the mineral survey, 1906–1907, pp. 12–17, London, 1908; idem for 1907–1908, p. 46, London, 1909.
[2] Recent discoveries of graphite in British African colonies: Imperial Inst. London Bull., 1908, pp. 186–189.
[3] Stutzer, O., Ueber Graphitgneise aus dem Hinterland von Lindi in Deutsch-Ostafrika: Deutsch. geol. Gesell. Monatsber Bd., 62, pp. 422–423, 1910. Stromer von Reichenback, E. F., Die Geologie der deutschen Schutzgebiete in Africa, p. 72, Munich, 1896.
[4] Bawden, E. R., Some observations on the graphite deposits of Africa: Chem., Met., and Min. Soc. South Africa Jour., vol. 13, p. 259, 1912.
[5] Ball, S. H., and Shaler, M. K., Economic geology of the Belgian Congo: Econ. Geology, vol. 9, p. 662, 1912.
[6] South Australia Dept. Mines, Semiannual reviews of mining operations, Nos. 26–28, 1917–18.
[7] Dunstan, B., Graphite: Queensland Govt. Min. Jour., vol. 18, pp. 454–455, 1917.
[8] Dunstan, B. op. cit., p. 455.
[9] Western Australia Dept. Mines Rept. for 1917, p. 4, 1918. Min. Mag., Feb., 1918, p. 86.

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coast, west of Esperance.[1] Samples from prospect shafts indicate a tenor in recoverable flake of 10 to 37 per cent. Other deposits of flake graphite deposits occur in the Kendenup district, Southwest division,[2] close to the line of the Great Southern Railway, 290 miles from Perth and 50 miles from Albany, the nearest shipping point. The graphite occurs in graphitic schist, and samples taken show a graphite content of 6 to 54 per cent, with picked samples carrying as much as 80 per cent. The flakes, however, are very small, mostly less than 0.5 millimeter in diameter.

Graphite deposits are said to occur in the interior of New Guinea.[3]

LITERATURE.

The following are the most important papers on graphite which have come to the attention of the writer since the issue of the last report.

1. ALLING, H. L., The Adirondack graphite deposits: New York State Mus. Bull. 199, Albany, 1918.
The descriptive portion of this paper has been summarized on page 237. In addition to the excellent description of the New York deposits the report contains much of general interest. The method of microscopic analysis developed by the writer is especially valuable. The microscopic analyses check surprisingly well with the chemical analyses where both are given and yield information as to the type of gangue minerals which is of great value to the miner and which is not shown by the chemical analysis.

2. BLEININGER, A. V., Notes on the crucible situation: Metal Industry, vol. 16, pp. 15–16, January, 1918.
The article contains a short discussion of the adaptability of graphite of different types to crucible manufacture and a detailed study of the properties of crucible clays.

3. DUB, G. D., Preparation of crucible graphite: Bur. Mines War Min. Inv. Ser. 3, December, 1918.
This paper is one of the most valuable contributions to the subject of graphite technology. A detailed review of mining conditions in Alabama, New York, Pennsylvania, and Texas is given. The various concentration processes are described in detail. The different methods in use are illustrated by flow sheets of typical mills and numerous sketches, and their efficiency is compared. Chemical and mechanical analyses of the finished products are given, and the author makes valuable recommendations for a standard grade of No. 1 flake and improved methods of sampling.

4. GILLETT, H. W., and RHOADS, A. E., Melting brass in a rocking electric furnace: Bur. Mines Bull. 171, 1918.
Does not deal directly with graphite but gives a comparison of costs between the electric furnace used and a coke-fired crucible furnace and shows that under war conditions a huge saving is possible by electric melting.

5. HORWOOD, C. B., The gold deposits of the Rand, London, 1917.
Chapter IV contains a discussion of the origin of graphite.

6. LEIGHOU, R. B., Chemistry of materials of the machine and building industries, New York, 1917.
Contains notes on the use of graphite in foundry facings, paints, and lubricants.

7. LYON, D. A., and KEENEY, R. M., Electric furnaces for making iron and steel: Bur. Mines Bull. 67, 1914.
Does not deal directly with graphite but describes electric-furnace practice. "Any product that can be made by the crucible furnace can be made by the electric furnace and in most cases with cheaper raw materials and at a lower cost."

[1] Blatchford, T., Interim report on the graphite deposits at Munglinup, Eucla Division: Western Australia Geol. Survey Bull. 76, 1917.
[2] Woodward, H. P., and Blatchford, T., The Kendenup graphite deposits: Western Australia Geol. Survey Bull. 74, Misc. Repts., ser. V, No. 68, pp. 94–101, 1917.
[3] Imp. Inst. Bull., vol. 15, p. 571, 1915.

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8. Miller, B. L., Graphite: Mineral Industry, 1917 (vol. 26), pp. 302–312, 1918.
A short review of the domestic and foreign graphite industry during 1917, with tables of production and imports.

9. Moses, F. G., Refining Alabama flake graphite for crucible use: Bur. Mines War Min. Inv. Ser. 8, December, 1918.
Results of experiments in raising low-grade concentrates to a flake of 90 per cent grade. Tests were made with an aspirator, pneumatic jig, pebble mill, electrostatic separator, oil flotation, and burr mill. The processes recommended are a dry process, consisting of treatment in the electrostatic separator followed by grinding in the burr mill and screening, and a wet process, involving crushing in the pebble mill, concentration by oil flotation, drying, and final grinding in the burr mill, followed by screening. The burr mill was found to be a necessity in the finishing process, where a 90 per cent product was required.

10. Newland, D. H., The mining and quarry industry of New York State: New York State Mus. Bull. 196, 1918.
Graphite, pp. 259–262. Contains description of the mine of the Joseph Dixon Crucible Co. at Graphite, the mines of the Graphite Products Corporation near Saratoga Springs, and the Hooper Brothers' mines near Whitehall.

11. Prouty, W. P., Alabama graphite in 1918: Eng. and Min. Jour., vol. 107, No. 4, pp. 194–195, 1919.
Gives a summary of recent changes in milling practice and the price schedule adopted by the Graphite Producers Association in the autumn of 1918.

12. Searle, A. B., Refractory materials, their manufacture and uses, London, 1917.
Contains notes on the use of graphite in the manufacture of crucibles, fire bricks, and other refractory products.

13. Spearman, Charles, The graphite industry: Canadian Min. Jour., vol. 40, pp. 87–88, Feb. 12, 1919.
Proposes the following flake standards: No. 1 flake should all be above 90-mesh in size, and over half should rest on a 50-mesh screen, and it should contain 85 to 90 per cent graphitic carbon; No. 2 flake should pass through 90-mesh and rest on 120-mesh standard screen. States that experiments showed that 100 grams of Alabama flake, shaken down, occupies 150 cubic centimeters, and the same weight of Canadian flake, 135 cubic centimeters, while 100 grains of Ceylon graphite occupies only 91 cubic centimeters.

14. Toronto University, Department of Mining Engineering, Preliminary report of an investigation into the concentration of graphite from some Ontario ores: Canadian Min. Jour., vol. 40, pp. 189–197, 1919.
A series of experiments is described and the following system is outlined: (1) Crush wet in a rod or ball mill, using an excess of water and the minimum of crushing compatible with the liberation of the maximum of coarse flake; (2) Remove the large flake by oversize screening; (3) Divide the sands into several grades by hindered settling classification; (4) Float each grade separately and by stages, regulating the quantity of oil to the requirements of each stage, making concentrates, middlings, and waste; (5) Regrind the concentrates and middlings separately in a rod mill with excess of water; (6) Screen wet, making a high-grade flake and a dirty undersize to be returned for flotation.
The advantages claimed over the older processes are these: (1) The whole process is wet, eliminating the dust nuisance and avoiding the necessity of drying large quantities of rock; (2) the minimum destruction of flake, owing to its rapid removal, and the minimum of crushing required combine to produce a maximum of coarse flake; (3) separation of the sands into grades renders possible the saving of some high-carbon flake that may not require regrinding, and the sizing of the material helps the separation of graphite and mica in the subsequent flotation; (4) the final product is a flake which is thicker, has a larger proportion of the coarser sizes, and is more brilliant in appearance than flake that is finished by a dry grinding process; (5) the process is simple and does not call for an elaborate flow sheet.

15. Wilson, M. E., Graphite in Port Elmsley district, Lanark County, Ontario: Canada Geol. Survey Summary Report, 1917, pt. E., pp. 29–42, 1918.
Consists chiefly of a geologic description of the Globe mine. The workable graphite ore occurs on the crest of an anticline, in silicified limestone, associated with intrusive pegmatite. This position of the graphite ore and its association with the completely silicified limestone are evidences that the original source of the graphite was the carbonate of the limestone, dissociated by the intrusive pegmatite.

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SLATE.

By G. F. Loughlin and A. T. Coons.

PRODUCTION.

GENERAL STATISTICS.

The value of the slate sold by the slate quarrymen of the United States in 1918 was $4,038,770. This shows a decrease of 30 per cent ($1,711,196) from the value for 1917. The total values for these two years can not reasonably be compared, as the figures for 1918 do not include a considerable value of output for slate granules for patent roofing, which was used in large quantities in the construction of the Government and other buildings necessitated by the war. Figures of slate granule production in 1918 are withheld so as not to disclose confidential information. The only slate product that showed increase in value in 1918 was mill stock, although the quantity sold showed a decrease.

Slate sold in the United States, 1909–1918.

Year.	Roofing slate.			Mill stock.			Other uses (value).	Total value.
	Number of squares (100 sq. ft.).	Value.	Average price per square.	Quantity (square feet).	Value.	Average price per square foot.		
1909	1,133,713	$4,394,597	$3.87	5,112,894	$876,089	$0.171	$170,732	$5,441,418
1910	1,260,621	4,844,664	3.84	5,181,498	999,098	.192	392,997	6,236,759
1911	1,124,677	4,348,571	3.87	5,744,577	1,027,605	.178	351,843	5,728,019
1912	1,197,288	4,636,185	3.87	5,765,273	1,013,220	.176	393,913	6,043,318
1913	1,113,944	4,461,062	4.00	6,312,011	1,233,838	.195	480,576	6,175,476
1914	1,019,553	4,160,832	4.08	5,361,925	977,930	.182	568,025	5,706,787
1915	967,880	3,746,334	3.87	4,576,112	819,672	.179	392,909	4,958,915
1916	835,873	3,408,934	4.08	5,782,842	1,177,260	.20	752,643	5,338,837
1917	703,667	3,411,740	4.85	5,478,151	1,277,249	.23	[a]1,060,977	5,749,966
1918	379,817	2,219,131	5.84	4,841,133	1,498,164	.31	[a]321,475	[b]4,038,770
Percentage of increase or decrease	−46.0	−35.0	.....	−11.6	+17.3	.....	−69.7	[b]−30

[a] Includes, in 1917, 4,378,490 school slates, valued at $48,828, and 2,650,563 square feet of blackboard material, valued at $413,163; in 1918, 1,244,740 school slates, valued at $17,016, 1,607,849 square feet of blackboard material, valued at $264,921, and 89,074 square feet of billiard-table material, valued at $33,502, and excludes value of slate granules in 1918.

[b] Value for 1918 is exclusive of value of slate granules.

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ROOFING SLATE.

Roofing slate, with a decrease in quantity of 46 per cent, continued the decline, which has been continuous since 1912 and general since 1902, as shown in the accompanying diagram.

The quantity sold in 1918, 379,817 squares, was the smallest ever recorded by the Survey. These figures represent sales made by quarrymen. Besides this, however, more than 20,000 squares of roofing slate was sold in 1918 by firms that make a practice of buying and storing the output of small quarries and later placing the product on the market as demand requires. This output was accounted for in the published figures of sales for previous years.

The value of roofing slate, after a slight gain of 0.08 per cent in 1917, showed a decrease of 35 per cent ($1,192,609). The total value for 1918 was $2,219,131 and was the lowest reported since 1888. The average price per square, which until 1914 had never exceeded $4, was $5.84 in 1918, 99 cents more than in 1917.

The producers of roofing slate report that 1918 was the most unsatisfactory year they ever experienced. Many of the quarries were idle and most of those in operation were worked only part time. The nearness of the slate quarries to shipyards and munition plants made labor scarce and costly. Operating expenses were reported as increasing from 25 to 100 per cent. Coal was hard to obtain and some quarries remained closed on that account. Advances in price ranged from 50 cents to $1 a square, and it was stated that although the increase in price did not fully meet the increased cost of operating, the quarrymen continued operations to retain such labor as they had and to keep the quarries in good condition. In one section of Pennsylvania the demand for roofing slate was reported as normal, but in most regions the embargoes on permanent building operations, as well as local conditions, reacted against the industry.

The prices quoted for Pennsylvania slate f. o. b. quarries on January 1, 1919, ranged from $10 to $19 per square (subject to discount for prompt payment) according to size and quality of the slates. This shows a very large increase in price over the average value of $5.50 per square for the slate sold in this State in 1918.

An attempt at organization for the better handling of the output of roofing slate of several quarries in the Bangor district was made in 1917. Conditions prevailing in 1918 and the first months of 1919 have presented many difficulties for this work, and there has been only a little advertising through the trade papers thus far. It appears, however, that the present time, which marks the beginning of renewed building activity, affords a great opportunity for the presentation to the general public, and especially to architects, contractors, and construction engineers, of the undoubted merits of slate as a roofing material.

Roofing slate, according to some producers, was not given due recognition in the construction of houses for war workers and other war structures, owing to erroneous ideas regarding the weathering qualities of slate. One only needs to examine buildings with slate roofs from 50 to 75 years old in this country and from a century to more than two centuries old in Europe to become convinced that standard slate has demonstrated satisfactorily its weathering qualities over a much longer period than any other roofing material.

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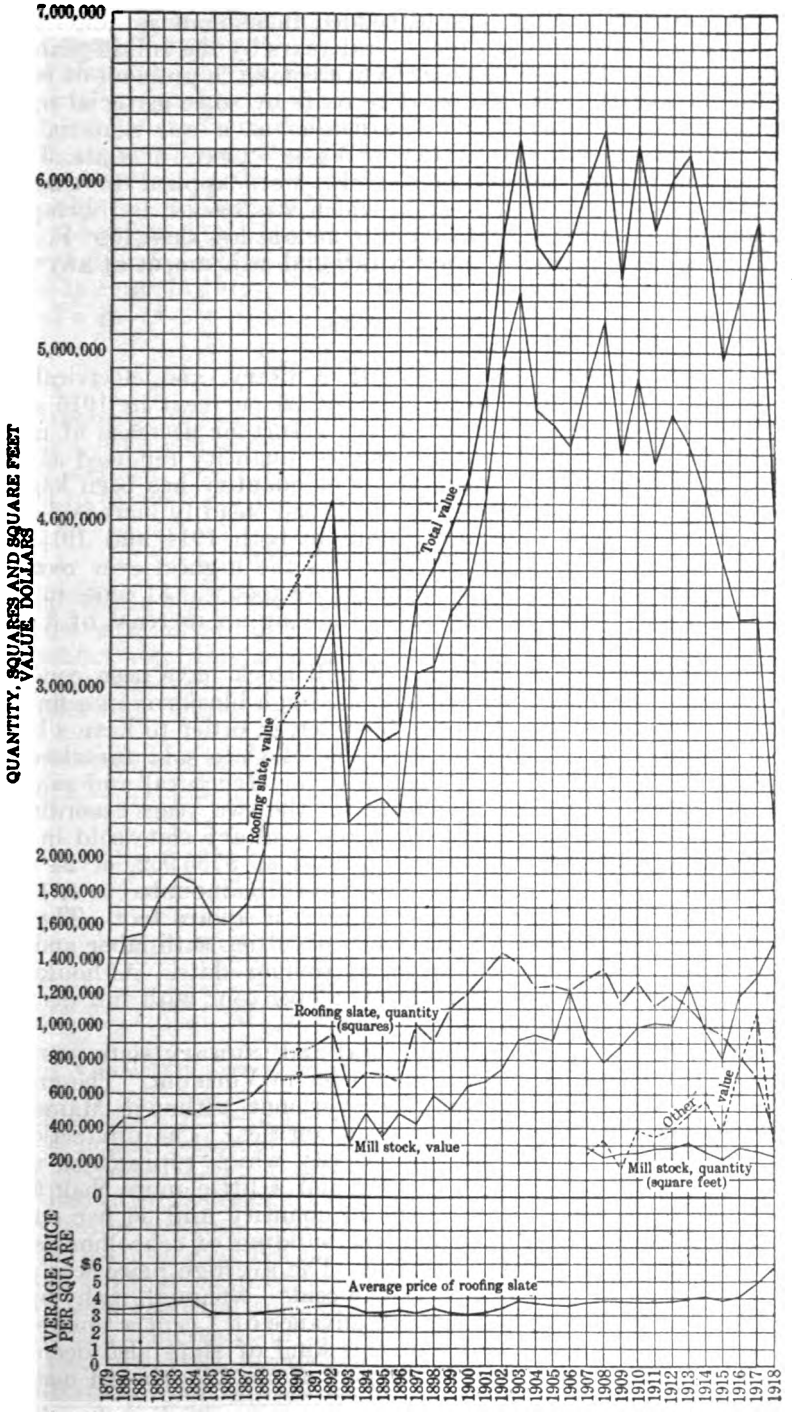

FIGURE 56.—Diagram showing production of slate in the United States from 1879 to 1918, inclusive. Number of square feet of mill stock is divided by 20 to show proper relation to roofing slate. The value of "other" slate in 1918 does not include that of slate granules.

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Small sizes of roofing slate embedded in asphalt as material for flat roofs have been utilized for several years by the Inlaid Slate Co., of Bangor, Pa. In 1918 in order to overcome the problem of replacing the metal flashings used on slate roofs by some material equally convenient, more lasting, and less needed as a war material, this company developed a substitute.[1] "Waste" pieces of slate, 3 by 6 inches, washed and heated to 200° F., were applied to three-ply standard Government roll roofing, which was backed by burlap and an asphaltic mixture guaranteed not to melt at less than 400° F. This material is cut in strips of usual width and adjustment at any angle provided for.

MILL STOCK.

Mill stock for slate for structural, sanitary, and electrical use, which had shown a gain in quantity of 26 per cent in 1916 and a decrease of 5 per cent in 1917, showed a further decrease of nearly 12 per cent in 1918, and was the smallest quantity reported as sold, except in 1908 and 1915, since record of quantity has been kept by the Survey. The value, however, which had steadily increased up to 1913 and underwent a decided slump in both 1914 and 1915, has steadily increased since and in 1918 was the highest ever recorded ($1,498,164). The average price per square foot was 31 cents in 1918, an increase of 8 cents in 1918, and following an increase of 3 cents in 1917.

In previous years the statistics of mill stock have been compiled according to the sale of the material as rough blocks or in a finished or partly finished state. In 1918, however, in order to have a better grasp on the uses of slate, the quantity of slate sold for electrical purposes was separated from that sold for structural and sanitary uses, so that a comparison of figures for the two years according to uses is not possible. The structural and sanitary slate sold in 1918 amounted to 3,129,194 square feet, valued at $756,952, or 24 cents a square foot. The electrical slate sold in 1918 amounted to 1,711,939 square feet, valued at $741,212, or 43 cents a square foot. The producers of mill stock reported the same difficulties with labor and cost of operation as the manufacturers of roofing slate. Although the price was reported as having advanced 25 per cent with fair demand, many quarries were idle.

Nearly 90 per cent of the structural and sanitary slate was produced in Pennsylvania and the remainder in Vermont. The greater part of the electrical slate was from Vermont, although Maine and Pennsylvania furnished considerable quantities. The production of slate for blackboards and bulletin boards, which represented about 7 per cent of the total value in 1917 and a little more than 6 per cent in 1918, decreased 39 per cent in quantity and 36 per cent in value in 1918. The curtailment of the building of schoolhouses was given as the reason for this decrease. The average price was practically the same in 1918 as in 1917—16 cents—although many operators reported that there had been an advance of 1 cent a square foot in price in 1918. The exports of this kind of slate also decreased considerably in 1918. The greater part of the blackboard material

[1] Stone, November, 1918, pp. 510–511.

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is furnished by Pennsylvania, but in 1918 some blackboard slate was reported from Vermont.

School slates showed an even greater decrease than blackboards—72 per cent in quantity and 65 per cent in value. All the school slates reported were from Pennsylvania. The exports of these slates increased about 27 per cent in quantity. The average price was $11.15 per thousand in 1917 and $13.67 per thousand in 1918.

Slate sold for billiard tables in 1918 amounted to 89,074 square feet, valued at $33,502, a decrease of 53 per cent in quantity and of 45 per cent in value. The average value was 32 cents a square foot in 1917 and 38 cents in 1918. The amount of slate exported for this use decreased over 34 per cent.

OTHER USES.

Slate reported for other uses included small quantities sold for tombstones, for use on roads, and as slabs for various purposes. Slate granules included under this heading in 1917 are excluded in 1918 so as not to disclose individual production.

COLORED SLATES.

Several of the companies in the New York-Vermont colored-slate belt report sales of two or more colors of slate and do not separate their product according to colors, but enough of them report regularly for the same color each year to afford the comparison furnished by the following figures:

Colored slates sold in New York and Vermont in 1909 and 1914–1918.

Year.	Red.	Green.			Purple.	Purple and green, mottled, variegated.	Total.
		Sea-green.	Unfading green.	Green.			
1909	$37,789	$758,372	$183,135	$246,612	$145,041	$443,430	$1,814,379
1914	36,256	789,055	81,884	190,265	121,935	307,628	1,527,023
1915	28,223	672,917	71,765	191,573	88,987	303,199	1,356,664
1916	16,039	529,875	51,328	122,487	265,523	328,154	1,313,406
1917	[a] 18,796	360,762	77,805	232,469	216,454	474,065	1,370,341
1918	[a] 11,383	343,309	42,574	237,182	175,656	430,709	1,240,813

[a] Value of 1,719 squares of roofing slate in 1917 and of 852 squares in 1918.

The decrease in 1918 in the total value of colored slates sold was 9.5 per cent and followed an increase of 4 per cent in 1917. The greatest decrease shown was for "unfading green" slate (45 per cent). Red slate decreased 39 per cent in value, but the quantity, 852 squares for roofing, decreased 50 per cent. All the "sea-green" slate reported was sold for roofing and amounted to 61,060 squares, valued at $343,309, a decrease of only 2 per cent in value. The "green" slate reported sold was 39,225 squares for roofing, valued at $237,182, an increase of 2 per cent in value. The "unfading green" slate was sold for roofing slate and as mill stock for structural, electrical, and billiard table use. The miscellaneous colored slates included 13,967 squares, valued at $99,965, and reported as

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"unfading green" and "mottled" slate. All the purple slate reported was mill stock and amounted to 541,822 square feet, valued at $175,656, a decrease of 19 per cent in value. This slate was sold chiefly for electrical use (477,422 square feet), but some was sold for billiard tables, blackboards, and structural slate. The slate included under the miscellaneous varieties is both roofing slate and mill stock and decreased 9 per cent in value in 1918.

SLATE INDUSTRY BY STATES.

Slate deposits in Arizona, Arkansas, California, Colorado, Georgia, New Jersey, and Tennessee were inactive in 1918, but sales were made from stock on hand in California, New Jersey, and Tennessee. It was reported to the Survey that the slate quarry near Placerville, Eldorado County, Calif., might be reopened in 1919. The slate granules annually reported from Utah have been omitted for 1918, in order to exclude this entire product, as explained on page 267.

Slate sold in United States, 1914–1918, by States.

State.	1914	1915	1916	1917	1918	Percentage of decrease, 1918.
California	.....	.....	(a)	(a)	(a)	.....
Maine	$277,419	(a)	(a)	(a)	(a)	.....
Maryland	77,391	$91,277	$71,737	$67,938	$42,113	—38.0
New Jersey	(a)	(a)	(a)	(a)	(a)	.....
New York	112,776	127,603	21,345	55,207	[b] 11,383	[b] —79.4
Pennsylvania	3,609,959	3,044,269	3,124,743	3,306,704	2,304,647	—30.3
Tennessee	.....	.....	.....	(a)	(a)	.....
Utah	(a)	(a)	(a)	(a)	(c)	(c)
Vermont	1,414,247	1,234,891	1,607,901	1,858,307	[b] 1,279,987	[b] —31.1
Virginia	204,139	210,612	165,483	135,380	109,723	—19.0
Undistributed	[d] 10,856	[e] 250,263	[f] 347,628	[g] 326,430	[h] 290,917	.....
	5,706,787	4,958,915	5,338,837	5,749,966	[b] 4,038,770	[b] —30.0

[a] Included in "Undistributed."
[b] Value for 1918 is exclusive of value of slate granules.
[c] Slate granules only produced, and figures excluded from total for United States in 1918.
[d] Includes New Jersey and Utah.
[e] Includes Maine, New Jersey, and Utah.
[f] Includes California, Maine, New Jersey, and Utah.
[g] Includes California, Maine, New Jersey, Tennessee, and Utah.
[h] Includes California, Maine, New Jersey, and Tennessee.

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Slate sold in the United States in 1917 and 1918, by States and uses.

State.	Number of operators.	Roofing slate.			Mill stock.						Other.	Total value.
					Manufactured.		Rough.		Total.			
		Number of squares (100 square feet.)	Value.	Average price per square.	Quantity (square feet.)	Value.	Quantity (square feet.)	Value.	Quantity (square feet.)	Value.		
1917.												
California	1			$8.16								(a)
Maine	3	5,153	$37,423	7.26								(a)
Maryland	4	9,909	66,462	6.71							1,476	$67,938
New Jersey	1			5.00								(a)
New York	9	3,069	27,511	8.96							27,696	55,207
Pennsylvania	72	457,393	2,110,044	4.61	3,400,402	$660,224	571,150	$49,968	3,971,552	$710,092	b 486,568	3,306,704
Tennessee	1			6.00								(a)
Utah	1											(a)
Vermont	38	201,487	1,031,525	5.12	779,174	255,541	162,897	26,354	942,071	281,895	544,887	1,858,307
Virginia	6	25,997	135,380	5.21								135,380
Undistributed c		659	3,395		564,528	285,262			564,528	285,262	350	326,430
	136	703,667	3,411,740	4.85	4,744,104	1,201,027	734,047	76,222	5,478,151	1,277,249	1,060,977	5,749,966

a Included in "Undistributed."

b Composed of 1,244,740 school slates, valued at $17,016; 1,592,849 square feet of blackboard material, valued at $262,221, and 14,916 square feet of billiard table material, valued at $3,252, and slate for other uses, valued at $1,734.

c Includes California, Maine, New Jersey, Tennessee, and Utah.

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Slate sold in the United States in 1917 and 1918, by States and uses—Continued.

State.	Number of operators.	Roofing slate.			Mill stock.						Other.	Total value.
					Structural and sanitary.		Electrical.		Total.			
		Number of squares (100 square feet.)	Value.	Average price per square.	Quantity (square feet.)	Value.	Quantity (square feet.)	Value.	Quantity (square feet.)	Value.		
1918.												
California	1			$8.00								(a)
Maine	3	2,609	$26,417	9.79								(a)
Maryland	4	4,680	40,869	8.73							$1,244	$42,113
New Jersey	2			4.80								(a)
New York	8	852	11,383	13.36								b11,383
Pennsylvania	49	211,196	1,161,545	5.50	2,824,795	$686,999	406,514	$171,880	3,231,309	$858,879	c 284,223	2,304,647
Tennessee	1			5.00								
Vermont	36	144,338	866,168	6.00	304,399	69,953	869,254	309,273	1,173,653	379,226	34,593	b1,279,987
Virginia	4	15,590	109,723	7.04								109,723
Undistributed d		462	3,026				436,171	260,059	436,171	260,059	1,415	290,917
	108	379,817	2,219,131	5.84	3,129,194	756,952	1,711,939	741,212	4,841,133	1,498,164	321,475	b4,038,770

a Included in "Undistributed."
b Exclusive of value of slate granules.
c Composed of 1,244,740 school slates, valued at $17,016; 1,592,849 square feet of blackboard material, valued at $262,221; 14,916 square feet of billiard table material, valued at $3,252; and slate for other uses, valued at $1,734.
d Includes California, Maine, New Jersey, and Tennessee.

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MAINE.

Except a small quantity of roofing slate and slate for tombstones, all the slate quarried in Maine was for electrical uses. The value of the total output in 1918 decreased 11 per cent. Labor conditions were very unsatisfactory, as it was difficult for the quarryman to maintain an adequate working force in competiton with the attractive wages offered by the shipyards on the Maine coast. Prices were reported as higher than in previous years but not high enough to meet the increased expense of operation.

MARYLAND.

Maryland slate finds its use chiefly for roofing, and besides the lack of demand for this use the quarries were hampered by loss of labor to the shipyards and ammuniton plants.

NEW YORK.

In New York the slate sold was red slate for roofing—852 squares, valued at $11,383; the price per square ranged from $11.50 to $16. A considerable quantity of slate ground into granules for the manufacture of patent roofing is not included.

PENNSYLVANIA.

The value of the slate sold by the quarrymen in Pennsylvania in 1918 ($2,304,647) was less than in any year since 1896. The decrease in value in 1918 amounted to $1,002,057 (30 per cent) and followed increases of 6 per cent in 1917 and 3 per cent in 1916. Although a portion of the Pennsylvania slate (7 per cent of the total value) was sold for electrical uses and therefore came under the head of an essential commodity, the remainder was practically all furnished to the building industry and was therefore severely affected by the embargoes incidental to all structural materials. These embargoes included regular roofing slate, structural and sanitary slate used in interior building and blackboard and bulletin boards. Lack of transportation doubtless accounted for the decreased export trade in blackboards, school slates, and slate pencils. Pennsylvania, however, continued to rank first among the slate-producing States with 57 per cent of the total value of the output in 1918, practically the same as in 1917.

Roofing slate decreased 54 per cent in quantity and 45 per cent in value in 1918. In 1917 there was a decrease of 14 per cent in quantity, with an increase of 3 per cent in value. In 1917 the average price per square increased 74 cents; in 1918 it increased 89 cents, with the prospect of further increase for 1919. In 1917 Pennsylvania slate represented 65 per cent of the total quantity and nearly 62 per cent of the total value of all roofing slate sold in the country. In 1918 these figures were 56 per cent of total quantity and 52 per cent for total value. This percentage of total production lost by Pennsylvania in 1918 was gained by Vermont.

In 1917 the figures for mill stock reported by Pennsylvania included some slate for electrical use. In 1918 the slate sold for elec-

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trical use was separated from that sold for structural and sanitary use and amounted to 406,514 square feet, valued at $171,880. If this is included with mill stock for structural and sanitary use, for comparison, mill stock decreased about 19 per cent in quantity but increased 21 per cent in value. The average price in 1918 was 27 cents per square foot—9 cents more than in 1917.

Slate blackboards, including bulletin boards, reported as sold in Pennsylvania in 1918, decreased 40 per cent in quantity and 37 per cent in value. There was an increase of less than 1 cent per square foot in the average price. Slate sold for school slates decreased 72 per cent in quantity and 65 per cent in value in 1918. Slate reported sold for billiard tables decreased 82 per cent in quantity and 84 per cent in value.

About 88 per cent of the total value of slate sold in Pennsylvania in 1918, as shown in the following table, was produced in Northampton County compared with 86 per cent in 1917. The remainder was quarried in Lehigh County. All the quarries in York County were idle.

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Slate sold in Pennsylvania in 1917 and 1918.

County.	Number of operators.	Roofing slate.			Mill stock.								Other (value).	Total value.
					Manufactured.		Rough.		Blackboards.		School slates.			
		Number of squares (100 square feet).	Value.	Price per square.	Quantity (square feet).	Value.	Quantity (square feet).	Value.	Quantity (square feet).	Value.	Number.	Value.		
1917.														
Lehigh	22	60,044	$280,088	4.66	181,610	$26,825	118,352	$18,195	674,298	$30,778	2,264,515	$28,012	$1,477	$435,375
Northampton	49	397,349	1,829,956	4.60	3,218,792	633,399	452,798	31,673	1,976,265	332,385	2,113,975	20,816	a 23,100	2,871,329
York	1			5.50										
	72	457,393	2,110,044	4.61	3,400,402	660,224	571,150	49,868	2,650,563	413,163	4,378,490	48,828	24,577	3,306,704

County.	Number of operators.	Roofing slate.			Mill stock.								Other (value).	Total value.
					Structural.		Electrical.		Blackboards.		School slates.			
		Number of squares (100 square feet).	Value.	Price per square.	Quantity (square feet).	Value.	Quantity (square feet).	Value.	Quantity (square feet).	Value.	Number.	Value.		
1918.														
Lehigh	13	21,548	$118,826	5.53	64,378	$15,518	214,145	$83,774	298,690	$39,977	514,033	$6,953	.....	$265,048
Northampton	36	189,648	1,042,719	5.50	2,760,417	671,481	192,369	88,106	1,294,159	222,244	730,707	10,063	a $4,966	2,039,599
	49	211,196	1,161,545	5.50	2,824,795	686,999	406,514	171,880	1,592,849	262,221	1,244,740	17,016	4,966	2,304,647

a In 1917 includes 84,966 square feet of billiard table material, valued at $20,527; in 1918, 14,916 square feet of billiard table material, valued at $3,252.

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The number of firms reporting sales in Pennsylvania in 1918 was 49—23 less than in 1917. Several reported sales from stock with quarries closed. The greater number of quarries operated only part time.

The operators commenting on the condition of the slate industry in 1918 all complained of labor conditions, that increase in prices did not cover increased cost of operations, and of decreased demand on account of ban on commercial building. Development work to prepare for an expected increase in business in 1919 was reported by one firm, and another company reported taking up work that did not pay in order to keep the quarries in good condition. The soft vein slate was reported as being especially hard hit and but few quarries were in operation. This slate, on acccount of its well-developed cleavage, softness, and comparatively dull luster, is in especial demand for blackboards and school slates. In the last two years three companies have been formed in Pennsylvania to act as selling agents for different classes of Pennsylvania slate. The Vendor Slate Co. buys the roofing-slate output of several quarries and markets it, the Natural Slate Blackboard Co. acts as selling agent for the blackboard material produced by several firms, and the Structural Slate Co. controls the output of electrical, structural, and sanitary slate. It is hoped by means of these central selling agencies to reduce the cost of marketing slate, to give more publicity to slate products, and to aid the industry by the cooperation of the quarrymen.

VERMONT.

Vermont, which ranks next to Pennsylvania in the production of slate, showed an apparent decrease in 1918 of $578,320 (31 per cent) in the total value of sales reported. The figures for 1918, however, do not include the sales of slate granules used in the manufacture of patent roofing, and an exact comparison of total value for the years 1917 and 1918 can not be made. Nearly 68 per cent of the value of Vermont slate represented in this report was for roofing slate in 1918, and this product decreased 28 per cent in quantity and 16 per cent in value. In 1917 Vermont produced 28 per cent of the quantity of roofing slate sold and in 1918, 38 per cent. The average price per square was $6, 88 cents more than in 1917.

In 1918 millstock amounting to 869,254 square feet, valued at $309,273, was sold for electrical uses. Including this with structural and sanitary slate, as in 1917, the total millstock output increased 25 per cent in quantity and 35 per cent in value. The average price per square foot was 30 cents in 1917 and 32 cents in 1918. Vermont for the first time reported sales of slate for blackboards and billiard tables.

Little comment on the conditions of the industry was made by the Vermont quarrymen. Business was dull, owing to war and labor conditions.

VIRGINIA.

Virginia's slate industry showed a decrease of 10,407 squares (40 per cent) in quantity and of $25,657 (19 per cent) in value in 1918.

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The average price per square increased from $5.21 in 1917 to $7.01 in 1918. Only four quarries were in operation. The others were closed on account of labor conditions, but with the expressed design of reopening as soon as conditions became normal.

EXPORTS.

ROOFING SLATE.

The value of the exports of roofing slate in 1918 was $65,224, more than twice as much as in 1917. As no record of quantity is kept for exports of slate and as prices rose so much higher in 1918 than in 1917, it is difficult to determine whether or not the quantity showed any large increase.

Roofing slate exported from the United States, 1913–1918.

1913	$226,413	1915	$46,137	1917	$27,113
1914	139,125	1916	27,630	1918	65,224

The following table was furnished by the Bureau of Foreign and Domestic Commerce, United States Department of Commerce:

Roofing slate exported from the United States, 1917 and 1918.

1917.

Canada	$19,245	West Indies—Continued.	
Mexico	93	Trinidad and Tobago	$111
Central America:		Other British West Indies	1,446
Guatemala	14	Virgin Islands	103
Panama	2,774	Dutch East Indies	492
South America:		Europe:	
Brazil	70	France	75
Colombia	40	Australia	2,450
British Guiana	5	British South Africa	19
Venezuela	136		27,113
West Indies:			
Barbados	17		
Jamaica	23		

1918.

Canada	$54,478	Hongkong	$94
Mexico	50	Philippine Islands	673
Panama	20	Dutch East Indies	49
South America:		French Oceania	1
British Guiana	290	Australia	4,371
Peru	220		65,224
Chile	4,000		
West Indies:			
Haiti	150		
Trinidad and Tobago	828		

Canada, as usual, was the largest consumer, taking 83 per cent of the slate exported. The greater part of the shipments to Canada were in the later part of 1918. It is possible that some of the roofing material manufactured from slate granules may be included in these exports, as it is known that slate granules were shipped to Canada.

The total imports of slate into Canada shown below are of interest in comparison with exports from the United States to Canada in 1916 and 1917, figures for 1918 not being available.

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Slate imported into Canada in 1916 and 1917.[a]

	1916	1917
Roofing slate	[b] $21,335	$20,785
School writing slate	35,887	40,603
Slate pencils	11,309	8,717
Slate of all kinds and manufactures of	28,245	36,788
	96,776	106,893

[a] McLeish, John, Preliminary report of the mineral production of Canada during the calendar year 1917, Canada Dept. Mines.
[b] Represents 4,412 squares.

Altogether slate valued at $83,783 was exported from the United States to Canada in 1918, compared with $51,941 in 1917. The value of other slate than roofing is shown in the next tables. Canada's production of roofing slate in 1917 was 1,422 squares, valued at $7,789,[1] and in 1918, 933 squares, valued at $5,124.

OTHER SLATE.

The following figures of exports of slate for other purposes than roofing were compiled from information furnished directly to the United States Geological Survey by producers and manufacturers. The only increase in quantity shown was in slate for electrical use (28 per cent), the other uses all showed decided decrease. The total value decreased 8 per cent. Electrical slate exported increased nearly 70 per cent in value. Billiard-table slate showed a slight increase in value of exports, as did also slate for pencils. The other products decreased. In 1917 South America received the greatest value of exported slate; in 1918 Asia was first (fourth in 1917), South America was second, and Canada was third (second in 1917). In Asia, China took more than one-half of the output chiefly in the form of slate pencils.

[1] McLeish, John. Preliminary report of the mineral production of Canada during the calendar year 1918, Canada Dept. Mines.

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Slate, other than roofing, exported in 1917 and 1918.

Country.	Electrical.		Structural.		Blackboards.		Billiard tables.		School slates.		Slate pencils.		Total value.
	Quantity (square feet).	Value.	Quantity (square feet).	Value.	Quantity (square feet).	Value.	Quantity (square feet).	Value.	Quantity (cases).a	Value.	Quantity (cases).a	Value.	
1917.													
Canada and Newfoundland	4,914	$2,687	3,000	$600	42,440	$8,500	.....	.....	3,537	$20,926	.....	.....	$32,713
Mexico	720	620	.....	.....	.....	.....	396	$77	15	82	.....	.....	779
Central America	20	17	.....	.....	13,682	2,350	897	206	813	5,345	1,000	$6,612	14,530
West Indies	4,940	4,199	790	509	3,934	1,040	3,262	468	979	6,261	.....	.....	12,477
South America	4,920	4,087	250	113	24	5	2,184	435	7,822	47,031	4,000	26,448	78,119
Europe	4,662	2,683	.....	.....	.....	.....	.....	.....	166	784	.....	.....	3,467
Africa	220	187	.....	.....	310	30	.....	.....	2,531	16,601	.....	.....	16,818
Oceania	2,540	2,159	.....	.....	.....	.....	.....	.....	3,366	21,713	.....	.....	23,872
Asia	5,200	4,420	.....	.....	.....	.....	78	16	3,453	17,379	.....	.....	21,815
	28,136	21,059	4,040	1,222	60,390	11,925	6,811	1,202	22,682	136,122	5,000	33,060	204,590
1918.													
Canada	10,883	7,215	.....	.....	8,025	1,605	39	12	2,804	20,473	.....	.....	29,305
Mexico	1,900	2,147	.....	.....	.....	.....	433	130	146	507	.....	.....	2,784
Central America	80	91	.....	.....	.....	.....	632	190	1,762	12,526	300	3,081	15,888
West Indies	2,520	2,848	1,285	525	4,262	985	1,989	597	435	2,447	.....	.....	7,402
South America	7,400	8,374	.....	.....	.....	.....	1,150	345	3,124	24,154	300	3,081	35,954
Europe	3,340	3,774	.....	.....	.....	.....	235	71	470	1,784	.....	.....	5,629
Africa	360	407	.....	.....	.....	.....	.....	.....	1,535	11,325	750	7,703	19,435
Oceania	2,820	3,186	.....	.....	.....	.....	.....	.....	3,115	15,296	800	8,216	26,698
Asia	6,580	7,436	.....	.....	.....	.....	.....	.....	3,130	23,168	1,300	13,864	44,468
	35,883	35,478	1,285	525	12,287	2,590	4,478	1,345	16,521	111,680	3,450	35,945	187,563

a Cases weigh from 130 to 165 pounds each; average is 135 pounds.

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IMPORTS.

Imports of slate for consumption in the United States have continued to decrease until they are practically negligible. The total values for the last four years have been $2,768 in 1915, $2,200 in 1916, $1,024 in 1917, and $321 in 1918. No sources of these imports are stated.

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GYPSUM.

By R. W. Stone.[1]

PRODUCTION.

Nearly 24 per cent less gypsum was mined in the United States in 1918 than in 1917, owing to a reduction in building operations. The output was less than that in any year since 1909, and the great reduction may be ascribed wholly to the war.

Crude gypsum mined in the United States, 1908–1918, in short tons.

1908	1,721,829	1912	2,500,757	1916	2,757,730
1909	2,252,785	1913	2,599,508	1917	2,696,226
1910	2,379,057	1914	2,476,465	1918	2,057,015
1911	2,323,970	1915	2,447,611		

On the other hand, the total value of the crude and calcined gypsum produced in 1918 surpassed that of any other year. Since the Survey's advance chapter on gypsum in 1917 was published the principal producers of gypsum board, block, and tile have revised their figures showing the quantity and value of gypsum used in those products in 1917. The revised figures are here given, and the reason for the change is discussed on another page. According to the revised figures the increase in 1917 was $3,157,420, or 40 per cent, over the total value in 1916, as compared with an increase of $3,000,000 in the 10 years from 1907 to 1916. The increase in 1918 was $354,402, or 3 per cent, over the total value in 1917.

Total value of crude and calcined gypsum, 1908–1918.

1908	$4,075,824	1912	$6,563,908	1916	$7,959,032
1909	5,906,738	1913	6,774,822	1917	11,116,452
1910	6,523,029	1914	6,895,989	1918	11,470,854
1911	6,462,035	1915	6,596,893		

The increase in total value of product, in spite of a decrease of nearly 24 per cent in total quantity mined, was due to the war, which increased cost of production by raising wages and the cost of all supplies. The increase in total value was not general, however. In Michigan, New York, and Oklahoma the value increased, but in Iowa, Kansas, Ohio, Texas, and Wyoming the value was less than in 1917. In all the principal producing States the quantity mined was less.

[1] The statistical tables in this report are the work of Miss L. M. Jones, statistical clerk, with the exception of those relating to imports and exports, which are compiled from the records of the Bureau of Foreign and Domestic Commerce by J. A. Dorsey.

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Status of gypsum industry in principal States in 1918, as compared with 1917.

State.	Decrease in quantity mined (per cent).	Increase or decrease in value (per cent).
Iowa	29	− 5
Kansas	30	−19
Michigan	24	+12
New York	12	+16
Ohio	26	− 5
Oklahoma	20	+13
Texas	39	−16
Wyoming	25	− 1

This table shows that the gypsum industry in New York had little to complain of in comparison with the industry in other States. Doubtless the better business conditions in New York were due to its closer geographic relation to the district in which the greatest amount of building was done and to its better equipment for delivering large quantities of gypsum board and block.

Of the States whose production is not shown separately it is interesting to note that the decrease in the quantity of gypsum mined in Colorado and New Mexico was only 5 to 6 per cent, whereas the decrease in California, Arizona, Nevada, Montana, and South Dakota ranged from 16 to 30 per cent.

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Gypsum produced and marketed in the United States, 1917 and 1918.

State.	Number of plants reporting.	Total quantity mined (short tons).	Sold without calcining.				Sold as calcined plaster.		Total value.
			Ground for land plaster.		For Portland cement, paint, and other purposes.		Quantity (short tons).	Value.	
			Quantity (short tons).	Value.	Quantity (short tons).	Value.			
1917.									
Alaska, Arizona, Colorado, Illinois,[a] Minnesota,[a] Montana, Nevada, New Mexico, Oregon, South Dakota, Utah, Virginia, Washington,[a] Wisconsin[a]	15	400,681	48,174	$133,930	68,680	$148,686	222,723	$1,347,044	$1,629,660
California	3	30,552	(b)	(b)	(b)	(b)	[b] 28,978	[b] 96,718	96,718
Iowa	5	461,864	14,194	30,253	50,818	80,488	322,198	1,931,256	2,041,997
Kansas	4	79,331	(b)	(b)	(b)	(b)	[b] 75,910	[b] 424,611	424,611
Michigan	8	375,803	7,090	22,903	61,065	93,750	257,588	1,452,002	1,568,655
New York	6	606,268	5,298	20,235	218,094	400,836	295,646	1,872,347	2,293,418
Ohio	4	270,538	4,100	11,765	6,510	16,615	219,679	1,276,117	1,304,497
Oklahoma	4	158,017	(b)	(b)	(b)	(b)	[b] 134,962	[b] 562,767	562,767
Texas	5	257,328	(b)	(b)	(b)	(b)	[b] 220,963	[b] 996,262	996,262
Wyoming	5	55,844	(b)	(b)	(b)	(b)	[b] 38,695	[b] 197,867	197,867
	59	2,696,226	84,366	230,808	539,629	893,562	1,677,390	9,992,082	11,116,452
1918.									
Arizona, California, Colorado, Illinois,[a] Minnesota,[a] Montana, Nevada, New Mexico, Oregon, South Dakota, Utah, Virginia, Washington,[a] Wisconsin[a]	18	331,395	40,428	159,215	71,596	168,082	208,763	1,515,150	1,842,447
Iowa	5	327,927	10,546	37,823	47,173	122,325	218,178	1,786,266	1,946,414
Kansas	3	54,958	(b)	(b)	(b)	(b)	[b] 46,710	[b] 343,749	343,749
Michigan	8	286,768	5,892	23,876	40,716	107,562	207,059	1,629,711	1,761,149
New York	6	531,038	3,139	14,552	179,968	442,067	275,333	2,213,460	2,670,099
Ohio	4	199,456	4,391	19,277	9,614	29,295	162,626	1,191,077	1,239,649
Oklahoma	4	126,208			35,211	70,437	72,271	567,207	637,644
Texas	5	157,388	(b)	(b)	(b)	(b)	[b] 129,034	[b] 834,560	834,560
Wyoming	4	41,877	(b)	(b)	(b)	(b)	[b] 29,813	[b] 195,143	195,143

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Gypsum produced and marketed in the United States, 1913–1918.

Year.	Sold without calcining.											
	For Portland cement.			As land plaster.			For other purposes.			Total.		
	Quantity (short tons).	Value.	Average price per ton.	Quantity (short tons).	Value.	Average price per ton.	Quantity (short tons).	Value.	Average price per ton.	Quantity (short tons).	Value.	Average price per ton.
1913	[a] 408,221	[a] $600,913	$1.47	54,815	$95,953	$1.75	[a] 100	[a] $200	$2.00	463,136	$697,066	$1.51
1914	[a] 390,742	[a] 549,063	1.41	52,945	97,716	1.85	(a)	(a)	.....	443,687	646,799	1.46
1915	[a] 406,393	[a] 528,161	1.30	69,256	122,714	1.77	(a)	(a)	.....	475,649	650,875	1.37
1916	[a] 454,112	[a] 607,995	1.34	81,879	167,136	2.04	[a] 11,128	[a] 15,299	1.37	547,119	790,430	1.44
1917	[a] 526,881	[a] 867,123	1.65	84,366	230,808	2.74	[a] 12,748	[a] 26,439	2.07	623,995	1,124,370	1.80
1918	[a] 403,635	[a] 974,283	2.41	64,571	255,716	3.96	[a] 1,986	[a] 6,553	3.30	470,192	1,236,552	2.63

Year.	Sold calcined.														
	As plaster of Paris, wall plaster, Keenes cement, etc.			For dental plaster.			To glass factories.			As boards, tile, and blocks, and for other purposes.			Total.		
	Quantity (short tons).	Value.	Average price per ton.	Quantity (short tons).	Value.	Average price per ton.	Quantity (short tons).	Value.	Average price per ton.	Quantity (short tons).	Value.	Average price per ton.	Quantity (short tons).	Value.	Average price per ton.
1913	1,680,157	$5,858,785	$3.49	861	$4,168	$4.84	10,942	$21,797	$1.99	81,889	$193,006	$2.36	1,773,849	$6,077,756	$3.43
1914	1,565,937	6,038,777	3.86	641	3,374	5.26	(b)	(b)	.....	[b] 89,488	[b] 207,039	2.31	1,656,066	6,249,190	3.77
1915	1,520,308	5,776,826	3.80	534	2,376	4.45	11,861	26,620	2.25	81,017	140,196	1.73	1,613,720	5,946,018	3.68
1916	1,677,081	6,884,960	4.11	661	8,766	13.26	11,537	28,839	2.50	116,535	246,037	2.11	1,805,814	7,168,602	3.97
1917	1,531,535	8,873,176	5.79	991	7,672	7.74	13,808	72,558	5.25	131,056	1,038,676	7.92	1,677,390	9,992,082	5.96
1918	1,174,359	8,483,633	7.22	(c)	(c)	.....	13,567	84,928	6.26	[c] 140,343	[c] 1,665,741	11.88	1,328,269	10,234,302	7.70

[a] A small quantity of paint material included with gypsum sold for Portland cement.
[b] Some calcined gypsum sold to glass factories included with boards, tile, etc.
[c] Some dental plaster included with boards, tile, etc.

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The average price per ton of crude gypsum sold for use as retarder in Portland cement increased from $1.65 in 1917 to $2.41 in 1918. New York produced nearly 45 per cent of the gypsum sold for this purpose, as it is the nearest source of supply to the great cement industry in eastern Pennsylvania. Nearly 40 per cent of the gypsum sold for land plaster was produced in Virginia; Iowa ranked second and Nevada third in sales of gypsum used for this purpose. The average price per ton of land plaster rose from $2.74 in 1917 to $3.96 in 1918. Most of the 1,986 tons of crude gypsum sold for "other purposes" is gypsum shipped to manufacturers of gypsum products, and no information is available as to the form in which it is finally placed on the market.

Gypsum wall plaster, plaster of Paris, and Keenes cement increased in average value per ton from $5.79 to $7.22, but both the quantity and the total value of these products were less in 1918 than in 1917.

Keenes cement was formerly made in only two or three States, but in 1918 its manufacture was reported in 12 States by five companies. As one company objects to the publication of the figures separately, the quantity and value of Keenes cement is included with wall plaster. The inclusion of this high-priced material with wall plaster and plaster of Paris does not change the average price per ton for these common plasters more than 1 or 2 cents, because the quantity of Keenes cement produced annually is less than 20,000 tons. Prices for it ranged from $10 to $22 a ton in different States.

In 1916 and 1917 dental plaster was reported as produced in six States, but in 1918 it was reported by only one producer. To avoid revealing confidential information the quantity and value in 1918 have been added in with other material.

More than 60 per cent of the calcined gypsum reported sold to plate-glass factories was produced in Ohio, about one-fourth was produced in Michigan, and the remainder in Iowa. The price increased from $5.25 to $6.26 per ton.

Plaster board, tile, and blocks were reported from 15 States at 28 plants operated by the original producers of the gypsum used in their manufacture, as compared with 19 plants in 12 States in 1917. Plants of firms that do not mine gypsum are not included here because the gypsum used by them is already accounted for in these tables as plaster sold by original manufacturers. Of the 134,979 tons of gypsum made into gypsum boards, block, and tile, New York produced 40,000 tons, Iowa 36,000, and Michigan 33,000.

Large quantities of gypsum board were used by the United States Government in the construction of temporary buildings required for the housing of both military and civilian organizations.

The supervisor of material purchase, housing section, Emergency Fleet Corporation, reported to the Geological Survey February 17, 1919, as follows: "We have used, approximately, 16,000 tons of gypsum plaster and 18,000,000 square feet of gypsum plaster board. We have also used a small quantity of gypsum partition tile, but the amount is negligible."

The manager of the construction division of the United States Housing Corporation stated in a letter to the Geological Survey February 6, 1919, that gypsum roof tile and partition tile were not used in any of the Housing Corporation's buildings, but submitted

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the following table showing the quantity of gypsum plaster and board used:

Gypsum products purchased and used by the United States Housing Corporation.

Project.	Gypsum wall board.	Gypsum plaster board.	Gypsum cement plaster.
	Square feet.	*Square feet.*	*Short tons.*
Aberdeen, Md.			240
Alliance, Ohio.			350
Bath, Me.			35
Bethlehem, Pa.	4,608,850		
Bridgeport, Conn.			1,486.45
South Charleston, W. Va.		116,430	264
Erie, Pa.			696
Indianapolis, Ind.		125,000	
Indianhead, Md.	504,115		
Moline, Ill.		786,600	
East Moline, Ill.		254,700	
New Brunswick, N. J.			408
New Castle, Del.	24,300		
Niagara Falls, N. Y.			776
Niles, Ohio.			100
Norfolk, Va.	3,916,192		1,574
New London, Conn.			375
Philadelphia, Pa.			1,755.67
Quincy, Mass.			1,061
Rock Island, Ill.		461,700	
Washington, D. C.	1,487,414	50,744	437
Watertown, N. Y.		63,200	
	10,540,871	1,658,374	9,558.12

The chief of the Construction Division of the War Department informed the Geological Survey in a letter dated February 8, 1919, that representative operations where gypsum wall board was used under various conditions and with different treatments were as follows:

Housing, Sun Village, Chester, Pa.; joints filled; papered.
Housing, Bethlehem, No. 24 project, Bethlehem, Pa.; same treatment.
Housing, Fairview project, Camden, N. J.; plaster board plastered with gypsum wall plaster and white coated.
Walter Reed Hospital, Washington, D. C.; joints covered with battens; painted.
General Hospital, Grand Central Palace, New York City; painted.
All Army camps and cantonments—Mills, Knox, Meade, Eustis, Custer, McClellan, etc.; nailed in place; no battens; no paint.
All hospital construction in 1918; painted or not; joints covered or not.
All aviation camps variously located; no battens; painted or not.
War Trade Board, Fuel Administration, and other buildings, Washington, D. C.
Dormitories, Washington, D. C.; plaster boards; joints covered; papered.

The quantity and value of gypsum reported as sold in 1917 for use as boards, tile, and blocks and for other purposes was 142,528 short tons, valued at $417,567, an average price per ton of $2.93. This average price was an increase of 39 per cent over the price in 1916 and was supposed to represent only the gypsum used in the board, tile, and blocks, and not the finished products. It was not clear, however, why the value of calcined gypsum so used should not be as great or greater than that of stucco and wall plasters, or between $5 and $6 a ton. The attention of the producers was called to this seeming discrepancy, and it was found that in some reports received the weight of steel reinforcing or other material used in

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gypsum blocks had not been deducted, so that the tonnage reported was too great, and that in some reports the value given had been the cost instead of the selling price of the finished product less cost of reinforcing, filler, paper, etc. The revised figures for 1917 are 131,056 short tons of gypsum sold for boards, tile, blocks, and other purposes, valued at $1,038,676, or an average price per ton of $7.93. In 1918 the quantity of gypsum sold for these purposes was 140,343 tons, valued at $1,665,741, or $11.88 a ton.

BUSINESS NOTES.

The Douglas Gypsum Block & Plaster Co., Douglas, Ariz., beginning in August, 1918, made a small output, mostly in the form of cast building blocks. Gypsite from a deposit 5 miles east of Douglas was used. Operations began with one kettle. In the arid climate of southern Arizona gypsum blocks have been used for many years for exterior as well as interior construction and successfully withstand exposure.

The Centerville Gypsum Co., Centerville, Iowa, was idle because the mine, which is reached by a shaft about 500 feet deep, is flooded.

The plant of the Wasem Plaster Co., Fort Dodge, Iowa, was burned May 16, 1918, and rebuilt later in the year.

The Kelly Plaster Co., Sandusky, Ohio, operated its plant at Castalia only 18 days, closing down January 18, 1918, because of inability to secure service from the railway line connecting with the plant.

The plant of the Southwest Cement Plaster Co., at Okeene, Okla., burned in August, 1918, and was not rebuilt.

The Colorado Portland Cement Co., of Denver, Colo., which has been leasing from the Red Buttes Cement & Plaster Co., at Red Buttes, Wyo., purchased that plant in December, 1918.

The Three Forks Portland Cement Co. mined gypsum at Cavern Spur, Gallatin County, and at Hanover, Fergus County, Mont. Cavern Spur is in the canyon of Gallatin River east of Cardwell, and the gypsum deposit is just below the limestone cave in the Lewis and Clark National Monument.

The Gypsum Industries Association, an organization composed of gypsum producers in the United States and representing 85 per cent of the product, maintains an office at 111 West Monroe Street, Chicago, Ill. The officers of the association are: President, R. C. Haynes, Acme Plaster Co., St. Louis, Mo.; vice president, J. C. Seguine, J. B. King & Co., New York, N. Y.; treasurer, J. A. Henley, American Cement Plaster Co., Chicago, Ill.; secretary, H. H. Macdonald; chief engineer, V. G. Marani; agronomist, Dr. Wm. Crocker.

Late in 1918 the War Service Committee on Gypsum established an office in Washington, D. C., with Virgil G. Marani, C. E., in charge. This committee assisted and cooperated with the building-materials section of the War Industries Board. The committee was prepared to furnish information regarding the uses of gypsum products in conformity with accepted engineering and architectural practice for gypsum plaster for all purposes; plaster board for lathing material; wall board for interior wall finish, suspended ceilings, and partition; furring and inclosure tile; poured monolithic roof construction; and

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precast slab roof construction. The committee could also furnish information regarding sources of supply, location of mines and mills, daily output, stocks, prices f. o. b. at mills, and freight rates. The Washington office was discontinued in January, 1919, but the Gypsum Industries Association formed a special service committee with V. G. Marani as secretary to serve until discharged by the War Industries Board.

MINE AND MILL DATA.

There were 68 active gypsum mines, quarries, and pits in the United States and Alaska, which supplied 57 domestic mills in 1918. Two mills sold ground gypsum only, 24 sold only calcined material, and 31 sold both calcined and uncalcined gypsum. Of the 57 mills, 40 used rock gypsum, 11 used gypsite, and the others used both gypsum and gypsite, except 1 plant, which reported the use of selenite crystals.

Practically all the mills are equipped with kettles for calcining. The fuel used was coal at 35 mills, oil at 12 mills, wood at 1 mill, coal and oil at 5 mills, and coke at 2 mills.

Fifteen mills reported the manufacture of Keenes cement and 23 mills reported making gypsum blocks or boards.

Domestic gypsum was calcined in 1918 at plants in the following places:

Arizona: Douglas.
California: Amboy.
Colorado: Loveland, Portland.
Iowa: Fort Dodge.
Kansas: Blue Rapids, Medicine Lodge.
Michigan: Alabaster, Grand Rapids, Grandville.
Montana: Hanover.
Nevada: Arden, Moundhouse.
New Mexico: Acme, Oriental.
New York: Akron, Garbutt, Oakfield.
Ohio: Castalia, Gypsum, Port Clinton.
Oklahoma: Acme, Eldorado, Okeene, Southard.
Oregon: Gypsum.
South Dakota: Black Hawk, Piedmont.
Texas: Acme, Plasterco.
Utah: Nephi, Sigurd.
Virginia: North Holston, Plasterco.
Washington: Tacoma (using Alaska gypsum).
Wyoming: Kane, Laramie, Red Buttes.

IMPORTS.

The decline from an annual importation of more than 400,000 tons prior to 1914 to imports of less than 60,000 tons in 1918 is a measure of the effect of the war on the manufacturers of gypsum products in the United States who generally import their raw material. Gypsum imported into the United States comes almost exclusively from Nova Scotia and New Brunswick. Of 50,653 tons imported crude in 1918, more than 50,000 tons came from Canada, less than 200 tons from England, and a few tons from China. The importation in several different months of 1 ton or less of crude gypsum from Hongkong, entering at Honolulu and San Francisco, is a peculiar fact, for which the writer is curious to find an explanation.

The value of manufactured plaster of Paris imported in 1917 was reported as $5,955. This was in error by the omission of pearl hardening valued at $61. In the following table the correction is made, the value in 1917 being $6,016. The total value of imports in 1918, $129,056, is only about one-ninetieth of the total value of the domestic production.

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Gypsum imported and entered for consumption in the United States, 1913–1918.[a]

Year.	Unground.		Ground or calcined.		Value of manufactured plaster of Paris.	Keenes cement.		Total value.
	Quantity (short tons).	Value.	Quantity (short tons).	Value.		Quantity (short tons).	Value.	
1913	447,383	$473,594	4,542	$31,277	$52,051	1,851	$26,185	$583,107
1914	369,214	392,118	3,559	27,931	24,792	1,007	17,511	462,352
1915	336,856	356,791	5,749	22,873	10,095	427	6,656	396,415
1916	254,131	275,043	11,706	72,345	9,085	600	9,890	366,363
1917	240,269	265,504	16,533	109,732	6,016	484	8,003	389,255
1918	50,653	55,004	6,117	70,028	1,765	111	2,259	129,056

[a] Figures compiled from records of the Bureau of Foreign and Domestic Commerce, Department of Commerce.

Imported gypsum from Nova Scotia was calcined in 1918 at New Haven, Conn., at New Brighton and New York City, N. Y., and at Chester, Pa. As the quarries commonly supplying these plants are on the Bay of Fundy, the rock is shipped by boat. Shipments can be made by rail, but this is not customary because of the higher cost. The War Trade Board restricted the importation of gypsum from overseas by licensing, and the United States Shipping Board used the fleet of J. B. King & Co., of New York, the largest importers, for coastwise movement of coal. Licenses were revoked June 11, 1918, except for such gypsum as might be carried on sailing vessels or by barges allocated for that purpose. Consequently imports for the year were very small.

EXPORTS.

The data in the following table were obtained from the Bureau of Foreign and Domestic Commerce, Department of Commerce. The figures for 1917 are for the first half of the year only, as during the second half plaster of Paris and plaster or wall board were included in "All other articles." Figures for plaster or wall board are available for all of 1918 and are given below.

Value of plaster of Paris and plaster or wall board exported, 1916–1918.

Country.	Plaster of Paris.			Plaster or wall board.		
	1916	1917	1918[a]	1916	1917	1918
Europe:						
Denmark		$16				
France	$50				$68	
Iceland, and Faroe Islands						$1,975
Italy		2			5	454
Norway					550	
Russia	3					
Spain		2		$63	632	
United Kingdom:						
England	141	81		30,094	7,765	15,394
Scotland	260					
North America:						
Bermuda	8	3		125		21
British Honduras	17	9			41	61
Canada	5,700	3,700		5,485	28,316	39,785
Central America:						
Costa Rica	40			15		
Guatemala	125	548			9	4,067
Honduras	54	24			4	
Nicaragua	44	2				
Panama	186	299		9	26	53
Salvador	14	2		82		1,181

[a] Plaster of Paris included under "All other articles."

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Value of plaster of Paris and plaster or wall board exported, 1916–1918—Contd.

Country.	Plaster of Paris.			Plaster or wall board.		
	1916	1917	1918	1916	1917	1918
North America—Continued.						
Mexico	$88	$409	.....	$328	$487	$3,518
Newfoundland	482	35	.....	.....	471	51
British West Indies:						
Barbados	10	.....	.....	.....	.....	.....
Jamaica	84	63	.....	38	.....	47
Trinidad and Tobago	24	80	.....	.....	66	.....
Other British	42	14	.....	103	.....	52
Cuba	3,394	11,225	.....	13,782	2,424	81,910
Virgin Islands	49	50	.....	500	.....	225
Dominican Republic	47	522	.....	20	.....	1,808
Dutch West Indies	.....	3	.....	.....	.....	.....
Haiti	14	311	.....	144	163	308
South America:						
Argentina	434	280	.....	2,622	12,813	12,031
Brazil	469	1,577	.....	50	864	4,907
Chile	45	45	.....	10,617	6,386	3,156
Colombia	126	157	.....	141	.....	.....
Ecuador	1	.....	.....	32	.....	.....
Guiana:						
British	43	41	.....	.....	.....	80
Dutch	.....	2	.....	.....	.....	.....
Peru	3	104	.....	.....	.....	4,574
Uruguay	58	8	.....	.....	1,046	.....
Venezuela	80	86	.....	46	.....	6
Asia:						
China	172	29	.....	.....	257	407
British East Indies:						
India	4	.....	.....	.....	5,232	4,585
Other British	.....	.....	.....	92	145	24
Dutch East Indies	248	.....	.....	.....	.....	5,440
Hongkong	.....	98	.....	.....	.....	170
Japan	167	55	.....	1,294	.....	113,931
Australia	31	.....	.....	26,249	36,696	70,796
New Zealand	78	66	.....	6,996	88	20,285
French Oceanis	.....	23	.....	.....	.....	65
Philippine Islands	.....	102	.....	.....	.....	10,608
Africa:						
British Africa:						
South	241	80	.....	6,447	1,419	13,786
West	.....	.....	.....	133	95	3,838
East	.....	.....	.....	.....	.....	2,386
Egypt	.....	.....	.....	2,998	.....	.....
	13,076	20,153	.....	108,505	106,118	421,985

Exports of plaster or wall board in 1918 were valued at $421,985, or nearly four times as much as for 1916. Japan alone took material valued at $113,931, or more than the total value of these exports in any previous year. The next largest buyers were Cuba, $81,910; Australia, $70,796, and Canada, $39,785. As the usefulness of gypsum plaster or wall board becomes better known the quantity exported should materially increase.

PRODUCTION OF GYPSUM IN CANADA.[1]

Because of the general cessation of building activities during the war, the production of gypsum fell in 1918 to less than one-quarter of the quantity mined in 1913. The difficulties in obtaining transportation by boat for shipments from the maritime Provinces was a contributory cause of the decreased output. The total quantity of gypsum rock quarried in Canada in 1918 was 155,298 tons, of which 88,748 tons was calcined.

[1] Preliminary report on the mineral production of Canada during the calendar year 1918, Canada Dept. Mines, Mines Branch.

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Gypsum produced and marketed in Canada, 1917 and 1918.

Year.	Quantity (short tons).	Value.
1917	336,332	$881,984
1918	152,287	823,006

The shipments of all grades amounted to 152,287 tons, valued at $823,006, and included lump gypsum, 43,728 tons, valued at $47,727; crushed, 25,074 tons, valued at $55,079; fine ground, 4,558 tons, valued at $12,621; and calcined, 78,927 tons, valued at $707,579. By provinces the shipments were: Nova Scotia, 49,365 tons, valued at $115,976; New Brunswick, 27,225 tons, valued at $214,114; Ontario, 38,214 tons, valued at $151,564; Manitoba, 37,483 tons, valued at $341,352.

GYPSUM IN FLORIDA.

Gypsum has been reported at only one locality in Florida, and this locality is not readily accessible, for it is a low-lying area of hummocky land, known as Bear Island, in the midst of a swamp about 6 miles west of Panasoffkee. It was examined by D. T. Day about 20 years ago. At the time of his visit there was a logging road across the swamp, but that road has been torn up, and the place is now less easy to reach. The following description is quoted from Day's report: [1]

> In the southern and southwestern portion of this so-called island the gypsum reaches the surface, with no covering whatever except an inch or two of vegetal mold. By striking a hoe into this the gypsum may be dug up in a soft state like clay, but it soon hardens on exposure to dry air. It is greenish while wet and turns white on drying. Where the gypsum is at the surface there are knolls from 10 to 50 feet square and 3 to 6 feet higher than the adjoining land, but the gypsum is found almost everywhere by slight excavation. The deposit is probably gypsite, or secondary gypsum.
>
> Two pits sunk through it have shown it to be 6½ feet thick in one place and 7 feet thick in the other, with the usual light Florida sand underneath. Mixed through it are boulders of very impure limestone, with occasional hard, flinty ones. As a rule the topography of the country will admit of digging 6 or 8 feet through the gypsum without encountering any considerable amount of water, except in the wet season.
>
> The quality of the gypsum is almost uniform in all the places from which specimens were taken. The quantity is evidently sufficient for a large supply. The only difficulty to be anticipated in the mining is the fact that the lumps of limestone would be encountered at irregular intervals; their character makes it evident that they are residual lumps from limestone which has been dissolved by the action of rain water, as in many other parts of the State. It is probable that the floor of the deposit will frequently be a bed of limestone, very irregular in its surface, so that it will be difficult to dig all the gypsum from it by cheap means.

According to a description by Prof. F. H. H. Calhoun, of Clemson College, S. C., there is at this locality a deposit of powdery to granular gypsum evidently formed from springs and of variable composition, varying from pure gypsum to 22½ per cent of calcium carbonate. He describes it as in places from 3 to 7 feet thick with an overburden of 3 feet and elsewhere from 6 to 12 feet thick without overburden. The following quotation is taken from Calhoun's description.[2]

[1] Day, D. T., Gypsum deposits in Florida: U. S. Geol. Survey Bull. 223, p. 48, 1904.
[2] Mineral Industry for 1917, p. 117, 1918.

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This deposit is probably the same one visited by Dr. Day, but he evidently did not see the best exposures. The material appears in sec. 23, T. 20, R. 21, as a huge mound from 6 to 10 feet thick. It has an average length of 150 yards and an average width of 60 yards.

North of this large deposit, which occurs on what is known as Soapstone Island, the deposits become thinner and less continuous. It might be best described as a swell or saucer type.

This type continues for some 200 yards and then gradually gives place to the type of deposit described by Dr. Day on Bear Island. The deposits on Bear Island consist of isolated mounds of gypsum from 6 to 100 feet in diameter and probably average 3 or 4 feet in thickness. I estimate that the deposit on Soapstone Island contains about 35,000 tons, the adjacent deposit about 70,000 and that on Bear Island probably as much, but so scattered as to make quarrying difficult. I found very little evidence that these mounds were connected under the surface.

Mr. Harry Houston, of Brooksville, Fla., has examined these deposits and finds that Bear and Soapstone islands are in the E. ½ sec. 23, T. 20 S., R. 21 E., and that the largest continuous deposit is on Soapstone Island, probably in the NE. ¼ SE. ¼ sec. 23. He sunk many holes with a 2-inch auger and found the deposit from 6 to 10 feet thick, with an average of 8 feet. On the north and west of the large deposit there are many more or less detached hummocks of gypsite. He reports one deposit "3 acres wide and 6 acres long with an average thickness of 8 feet," or approximately 231,000 cubic yards, and another "350 yards long and 140 yards wide with an average depth of 8½ feet," or approximately 131,800 cubic yards—a total of 362,800 cubic yards or about the same number of tons.

The writer visited this locality in March, 1919, and learned that gypsite occurs on Bear, Soapstone, and Burnt islands in the swamp west of Panasoffkee and also near Inverness. These islands are about 4 miles west of the Seaboard Air Line Railway at a point 3½ miles south of Panasoffkee. Pine land extends within about three-quarters of a mile of the islands, but the remaining distance is swamp grown up with saw grass more than head high, so that access from this direction is difficult. The islands are easily reached by small gasoline launch from Panasoffkee. It takes about three hours to make the trip across Panasoffkee Lake, up Withlacoochee River and Jumpers Lake, and thence by pole boat up Bear Island Creek to the islands.

The deposits are a soft, incoherent mass of fine gypsum crystals or particles having the character of gypsite. On Bear Island there are many hummocks of gypsite from 3 to 6 feet high, which are said to extend in a northeast direction for nearly a mile in a belt a quarter of a mile wide. According to these estimates, this would be approximately 160 acres, but as the hummocks are detached, with little or no gypsite between them, the available quantity probably is not more than 200,000 tons.

At the south end of Soapstone Island, which is half a mile long, there is an area of several acres in which gypsite forms a comparatively level-topped deposit rising about 10 feet above water level. Bordering it on the west and north are several acres of gypsite hummocks rising to 10 feet in height. The deposit at the south end of Soapstone Island is the largest compact body that has been discovered. Drill holes sunk in it by Harry Houston, of Brooksville, Fla., are reported by him to show an average thickness of 8 feet of

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gypsite. Several holes showed 7½ to 9½ feet of gypsite, and two holes 14 and 15 feet deep did not reach the bottom of the deposit.

The overburden consists of 2 or 3 inches of vegetable mold. There is over the whole area a forest cover of palmetto, cabbage palm, cypress, live oak, and other trees, with almost no underbrush. Overturned trees show a flat mass of roots but no tap roots. The bottom of the gypsite deposit seems to be practically at the level of the surrounding swamp, and the gypsite is probably always damp. It might not be difficult to strip off the forest and leave a clean surface of gypsite, but as the highest estimate of available tonnage is only about 360,000 tons a moderate business of 50,000 tons annually would exhaust the deposit in six or seven years. A conservative estimate of 150,000 tons available and a small plant having a capacity of 20,000 tons a year gives the same result—exhaustion in a brief period. Although the deposits could be mined by steam shovel or floating dredge, they have not been developed because of their small size and location in an area of small market, which is easily supplied by gypsum producers in Virginia, and those in the Atlantic Coast States using gypsum from Nova Scotia.

Samples of gypsite were taken by the writer for analysis.

Analyses of gypsite from Florida.

[Chase Palmer, analyst.]

	Bear Island.	Soapstone Island.
Calcium oxide (CaO)	32.39	32.30
Sulphur trioxide (SO_3)	44.10	45.00
Water, loss on ignition, etc	21.64	21.53
Ferrous oxide (Fe_2O_3)	.52	.32
Silica (SiO_2)	.55	.26

The Bear Island sample was obtained by cleaning off a few inches from the face of an exposure to get unstained material free from vegetation. The Soapstone Island sample was dug 2 feet below the surface in the side of a vertical wall of a hole in the deposit. These analyses are practically identical with that of the sample obtained by Dr. Day.

According to geologic maps of Florida, the area west of Panasoffkee is occupied by rocks of the Vicksburg group, of Oligocene age. This group consists of soft, porous light-gray to white limestone, containing marl beds and layers of chert. The writer did not find limestone exposed near the gypsite deposits but did see nodules of fossiliferous chert between the hummocks of gypsite. The meager evidence suggests, as mentioned by Calhoun, that the gypsite has been derived from springs. It would seem that at some earlier geologic period the land stood at a slightly higher elevation and that gypsiferous waters rising under artesian head reached the surface here and, evaporating, made mounds of gypsite.

According to Mr. S. Stephens, Bushnell, Fla., there is considerable gypsite on Burnt Island, which lies about 200 yards east of the north end of Soapstone Island, and also near Inverness, a few miles north of the Soapstone Island locality. He reports that the deposit near

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Inverness is pockety, can be traced about 1½ miles, and does not contain more than 5,000 tons. Of this same deposit Calhoun[1] says:

> Farther north about 5 miles east of Inverness more deposits are found, but in these the type is different. It lies beneath the surface, covered with an overburden from a few inches to several feet in thickness. The deposit itself, I believe, would not average more than 3 feet and is not continuous. This deposit extends south some 2 or 3 miles.

USES.

The uses of gypsum are described in Bureau of Mines Technical Paper 155, "Gypsum products, their preparation and use," by R. W. Stone, 1917,[2] and briefly in Mineral Resources of the United States for 1915 and 1917. In the report for 1917 mention that a patent had been issued for cleaning wool with overburned gypsum was made on information received from a gypsum producer in the Southwest. The use of gypsum for this purpose has not been confirmed.

Several uses not mentioned in these reports have recently come to the writer's attention. Gypsum may be used as an acid reacting material in baking powder. The purchase of considerable quantities of gypsum by large bakeries is not therefore an evidence of food adulteration. Broken pottery molds, a waste product of potteries, are used as a retarder in Portland cement. The old molds are run through a light crusher and used instead of crude gypsum. This same waste material may be used also as agricultural gypsum.

MANUFACTURERS.

MANUFACTURERS OF GYPSUM PLASTER.

HEAD OFFICES.

Acme Cement Plaster Co., St. Louis, Mo.
American Cement Plaster Co., Chicago, Ill.
American Gypsum Co., Port Clinton, Ohio.
Arden Plaster Co., Los Angeles, Calif.
Arizona Gypsum Plaster Co., Douglas, Ariz.
Best Bros. Keenes Cement Co., Medicine Lodge, Kans.
Cardiff Gypsum Plaster Co., Fort Dodge, Iowa.
Colorado Portland Cement Co., Denver, Colo.
Connecticut Adamant Plaster Co. (importer), New Haven, Conn.
Consolidated Pacific Cement Plaster Co., Los Angeles, Calif.
Dakota Plaster Co., Rapid City, S. Dak.
Douglas Gypsum Block & Plaster Co., Douglas, Ariz.
Empire Gypsum Co., Rochester, N. Y.
Globe Plaster & Mining Co., Kansas City, Mo.
Grand Rapids Gypsum Co., Grandville, Mich.
Grand Rapids Plaster Co., Grand Rapids, Mich.
Higginson Manufacturing Co. (importer), Newburg, N. Y.
Jumbo Plaster & Cement Co., Sigurd, Utah.
Kelly Plaster Co., Sandusky, Ohio.
Keystone Plaster Co. (importer), Chester, Pa.
J. B. King & Co. (importer), New York, N. Y.

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[1] Op. cit., p. 117.
[2] Obtainable only from Superintendent of Documents, Government Printing Office, Washington, D. C., for 20 cents a copy.

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Lycoming Calcining Co., Williamsport, Pa.
Michigan Gypsum Co., Grand Rapids, Mich.
Nephi Plaster & Manufacturing Co., Salt Lake City, Utah.
Niagara Gypsum Co., Buffalo, N. Y.
Overland Cement Plaster Co., Laramie, Wyo.
Pacific Coast Gypsum Co., Tacoma, Wash.
Pacific Portland Cement Co., San Francisco, Calif.
Plymouth Gypsum Co., Fort Dodge, Iowa.
Rock Plaster Manufacturing Co. (importer), New York, N. Y
Southern Gypsum Co., North Holston, Va.
Southwest Cement Plaster Co., Wichita, Kans.
Texas Cement Plaster Co., Oklahoma City, Okla.
Three Forks Portland Cement Co., Hanover, Mont,
United States Gypsum Co., Chicago, Ill.
Wasem Plaster Co., Fort Dodge, Iowa.

MANUFACTURERS OF GYPSUM PLASTER OPERATING MORE THAN ONE PLANT.

Acme Cement Plaster Co.....	Grand Rapids, Mich.
	Acme, Okla.
	Acme, Tex.
	Acme, N. Mex.
	Laramie, Wyo.
	Gypsum, Oreg.
American Cement Plaster Co.....	Akron, N. Y.
	Gypsum, Ohio.
	Grand Rapids, Mich.
	Fort Dodge, Iowa.
	Blue Rapids, Kans.
	Acme, Tex.
Colorado Portland Cement Co.....	Portland, Colo.
	Primm, Okla.
	Red Butte, Wyo.
Grand Rapids Plaster Co.....	Grand Rapids, Mich.
	Grandville, Mich.
United States Gypsum Co.....	Oakfield, N. Y.
	Plasterco, Va.
	Gypsum, Ohio.
	Alabaster, Mich.
	Grand Rapids, Mich.
	Fort Dodge, Iowa.
	Blue Rapids, Kans.
	Southard, Okla.
	Eldorado, Okla.
	Piedmont, S. Dak.
	Loveland, Colo.

MANUFACTURERS OF KEENES CEMENT.

Acme Cement Plaster Co., 703 Frisco Building, St. Louis, Mo.
Best Brothers Keenes Cement Co., Medicine Lodge, Kans.
Nephi Plaster & Manufacturing Co., 322 Ness Building, Salt Lake City, Utah.
Pacific Portland Cement Co., 827 Pacific Building, San Francisco, Calif.
United States Gypsum Co., 205 West Monroe Street, Chicago, Ill.

MANUFACTURERS OF GYPSUM PLASTER BOARD AND WALL BOARD.

American Cement Plaster Co., 111 West Washington Street, Chicago, Ill.
Bell, H. W., & Co., 2592 Park Avenue, New York City.
Bestwall Manufacturing Co., 25 North Dearborn Street, Chicago, Ill.
Buttonlath Manufacturing Co., Vernon and Boyle Avenues, Los Angeles, Calif.
Duffy, J. P., & Co., 51st Street and Second Avenue, Brooklyn, N. Y.
Gypsite Fireproofing Co., 2034 Dime Bank Building, Detroit, Mich.
Hercules Plaster Board Co., Hampton, Va.

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Kelley Plaster & Plaster Board Co., 261 Central Avenue, Passaic, N. J.
Keyhole Plaster Lath Co., 148 Hooper Street, San Francisco, Calif.
King, J. B., & Co., 17 State Street, New York City.
New Jersey Adamant Manufacturing Co., 79 Passaic Avenue, East Newark, N. J.
Pacific Coast Gypsum Co., 403 Perkins Building, Tacoma, Wash.
Plymouth Gypsum Co., Fort Dodge, Iowa.
Rader, Gustav, 1105 Metropolitan Avenue., Brooklyn, N. Y.
Reeb, M. A., Corporation, 597 Michigan Avenue, Buffalo, N. Y.
Rock Plaster Manufacturing Co., 381 Fourth Avenue, New York City.
Schumacher Wall Board Co., 58th Street, San Pedro and Slauson Avenues, Los Angeles, Calif.
Southern Gypsum Co., North Holston, Va.
United States Gypsum Co., 205 West Monroe Street, Chicago, Ill.

MANUFACTURERS OF GYPSUM BLOCK AND TILE.

Acme Cement Plaster Co., 703 Frisco Building, St. Louis, Mo.
American Cement Plaster Co., 111 West Washington Street, Chicago, Ill.
Arizona Gypsum Co., Douglas, Ariz.
Basin Cement Plaster Co., Stucco, Wyo.
Douglas Gypsum Block & Plaster Co., Douglas, Ariz.
Durfee, Seth, Kane, Wyo.
Keystone Plaster Co., Chester, Pa.
King, J. B., & Co., 17 State Street, New York, N. Y.
Michigan Gypsum Co., Grand Rapids, Mich.
Nephi Plaster & Manufacturing Co., 322 Ness Building, Salt Lake City, Utah.
Plymouth Gypsum Co., Fort Dodge, Iowa.
Reeb, M. A., Corporation, 597 Michigan Avenue, Buffalo, N. Y.
United States Gypsum Co., 205 West Monroe Street, Chicago, Ill.

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SAND AND GRAVEL.

By R. W. Stone.

INTRODUCTION.

The task of the Geological Survey in collecting the statistics of the production of sand and gravel in the United States has proved very difficult. The small dealers not infrequently are reluctant to give the quantity and value of their output, and many of the new producers do not realize the purpose of the Survey's work. This reluctance to furnish complete or satisfactory information is often due to the desire of the producer to keep all knowledge of his business from his competitors. He does not realize that the statistics of any particular individual or firm are held in strict confidence by the Survey and are not given out except by his special permission. The small independent producer should use every legitimate effort to foster his own enterprise, especially when he is surrounded by competitors, but it is to his interest that he and his business be known to the Survey, which may be able to turn more business his way.

In all statistical work the completed totals can be no better than the individual reports. If a man or a firm here and there fails to give the figures showing production and value, or makes erroneous statements, the accuracy of the tabulated statistics is to that extent impaired.

The work done by the United States Geological Survey in connection with sand and gravel is not confined to the tabulation and publication of the statistics of production. Information concerning these products is constantly being sought and compiled and is freely given to any inquirer. An engineer in New York may want a grade of sand that is especially fitted for some particular work there or elsewhere and may ask what source of supply is nearest to his project. The Survey promptly puts him in touch with the firm or firms that can best supply him sand in the quantity and of the quality he desires. A builder who is far from any source of gravel known to him and who wants to save both time and freight charges in obtaining his supply of gravel asks the Survey for information; or someone forwards to the Survey a sample of sand to learn its use and value and its possible buyers. The Survey tries to help each inquirer, thus benefiting both the producers and the consumers.

PRODUCTION.

Reports received by the United States Geological Survey from 2,800 producers show that 61,824,426 short tons (of 2,000 pounds) of sand and gravel were produced in 1918. However, the production in 1918 was 14,894,899 tons less than in 1917, when it was 76,419,325 tons. Nevertheless, the average price per ton in 1918 was 61 cents,

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or 33 per cent more than the average, 46 cents, received the year before, so that notwithstanding a heavily decreased output the value of the production in 1918 was $37,927,079, as compared with $35,296,932 in 1917, an increase of $2,630,147.

The producers found business better during the first half of the year, but after July 1, 1918, there was a pronounced decline in the volume of business. The date of this change coincides closely with the date when freight rates were increased. General Order No. 28 of the United States Railroad Administration, providing for an increase of 25 per cent on practically all commodities, went into effect June 25, 1918. The freight rates on sand and gravel were increased 1 cent for each 100 pounds, or 20 cents a ton, equal to about $6 or $7 a carload. An increase of this kind might not affect products of the higher grades, but it would and did affect those of the lower grades, which sell at the lowest prices.

For a closer insight into the business of 1918 as compared with that of 1917 the opinions of 634 producers of sand and gravel, representing the six States Michigan, Pennsylvania, New York, Illinois, Indiana, and Ohio, are summarized. Of these, 169, or 27 per cent, reported that their trade was better; 153, or 24 per cent, said that trade was about the same; and 312, or 49 per cent, indicated disappointment. Most dealers in glass and foundry sand were in the first category, and a few producers of paving sand were pleased, but nearly all of these were located where highways were under construction or being improved. Most of the 312 disappointed ones seemed to be producers of building and paving materials.

To meet the exigencies of war the entire output of some sand and gravel concerns was commandeered by the Government, and the operators accepted their fate with the same splendid spirit that was shown by other business men who also wanted to "do their bit" loyally.

The tables which follow have been prepared by Mrs. L. M. Beach, who also assisted in the preparation of the text.

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Sand and gravel produced in the United States in 1917 and 1918.

1917.

State.	Glass sand.		Molding sand.		Building sand.		Grinding and polishing sand.		Fire or furnace sand.		Engine sand.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Alabama			148,355	$54,742	157,107	$67,277	(a)	(a)			(a)	(a)
Arizona												
Arkansas	(a)	(a)	1,058	528	166,013	63,568					(a)	(a)
California	(a)	(a)	10,704	12,541	482,173	160,901	(a)	(a)	3,626	$2,686	(a)	(a)
Colorado			740	261	52,567	20,056			(a)	(a)	(a)	(a)
Connecticut			(a)	(a)	188,935	106,607	(a)	(a)				
Delaware			(a)	(a)	151,864	90,309			(a)	(a)		
Florida					48,148	19,448	(a)	(a)			7,084	$1,313
Georgia	(a)	(a)	31,793	8,950	257,880	78,409	6,600	$1,950			35,342	6,568
Hawaii					(a)	(a)						
Idaho												
Illinois	607,186	$679,618	703,208	412,626	2,592,774	932,455	129,605	167,414	85,051	54,834	133,715	33,586
Indiana	5,000	1,250	287,483	111,732	1,556,922	410,988	25,111	7,040	2,530	1,328	98,141	29,962
Iowa	(a)	(a)	72,844	26,028	1,194,878	372,756	(a)	(a)	(a)	(a)	21,093	6,146
Kansas					646,166	164,105					14,041	2,851
Kentucky	(a)	(a)	36,744	34,432	336,884	202,156			(a)	(a)	5,532	3,033
Louisiana	(a)	(a)			77,125	45,798					3,440	422
Maine					4,269	3,319						
Maryland	(a)	(a)	(a)	(a)	730,323	319,632	(a)	(a)	(a)	(a)	35,728	32,554
Massachusetts	(a)	(a)	26,701	18,643	666,487	355,498	(a)	(a)	6,221	9,263	(a)	(a)
Michigan			147,256	52,686	782,305	433,546	(a)	(a)	(a)	(a)	4,096	1,103
Minnesota			12,904	14,068	561,979	163,916	(a)	(a)	(a)	(a)	1,530	436
Mississippi			(a)	(a)	52,790	23,615					(a)	(a)
Missouri	153,970	162,838	90,811	58,608	1,018,719	449,596	(a)	(a)	(a)	(a)	21,170	9,289
Montana					2,200	1,699						
Nebraska			(a)	(a)	948,794	195,405					60,868	7,822
Nevada					17,733	1,756					405	150
New Hampshire					(a)	(a)						
New Jersey	100,448	93,194	611,916	651,279	1,818,275	545,437	95,741	127,244	118,682	121,295	58,552	30,319
New Mexico					(a)	(a)						
New York	(a)	(a)	650,427	808,550	3,836,257	975,512	65,669	32,322	(a)	(a)	19,057	9,655
North Carolina			(a)	(a)	151,209	68,093	(a)	(a)			(a)	(a)
North Dakota					(a)	(a)						
Ohio	161,408	276,619	999,974	1,218,217	2,318,904	1,090,689	57,449	122,673	149,776	292,231	91,629	76,189
Oklahoma	(a)	(a)	(a)	(a)	233,914	102,889					(a)	(a)

a Included in "Combined totals."

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Sand and gravel produced in the United States in 1917 and 1918—Continued.

1917—Continued.

State.	Glass sand.		Molding sand.		Building sand.		Grinding and polishing sand.		Fire or furnace sand.		Engine sand.	
	Quantity (shorttons).	Value.	Quantity (shorttons).	Value.	Quantity (shorttons).	Value.	Quantity (shorttons).	Value.	Quantity (shorttons).	Value.	Quantity (shorttons).	Value.
Oregon					59,234	$29,003						
Pennsylvania	462,972	$742,815	640,450	$696,734	1,996,524	1,319,624	480,955	$567,013	185,137	$175,022	414,315	$415,705
Rhode Island			(a)	(a)								
South Carolina			(a)	(a)	19,621	8,821					(a)	(a)
South Dakota					6,656	3,755						
Tennessee	(a)	(a)	33,971	18,833	323,731	183,695			3,885	2,176	27,132	8,843
Texas	6,894	6,484	2,678	3,813	326,370	162,880	(a)	(a)	(a)	(a)	22,936	5,960
Utah					65,398	25,365					2,300	272
Vermont			(a)	(a)	2,878	831	(a)	(a)				
Virginia	(a)	(a)	21,151	21,030	379,641	144,839	(a)	(a)	4,300	3,154	72,352	29,660
Washington			3,632	951	163,564	39,350					(a)	(a)
West Virginia	347,640	562,693	(a)	(a)	151,302	116,367	7,550	14,680	(a)	(a)	108,500	72,672
Wisconsin			97,674	53,846	787,480	295,952	(a)	(a)			(a)	(a)
Wyoming												
Combined totals	97,157	159,503	28,494	24,711	38,994	41,771	310,510	180,372	44,827	33,466	151,314	43,644
	1,942,675	2,685,014	4,660,968	4,303,809	25,374,987	9,837,688	1,179,190	1,220,708	604,035	695,455	1,410,222	832,834

a Included in "Combined totals."

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Sand and gravel produced in the United States in 1917 and 1918—Continued.

1917—Continued.

State.	Paving sand.		Filter sand.		Other sands.		Railroad ballast sand and gravel.		Gravel.		Total.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Alabama	(a)	(a)	(a)	(a)	(a)	(a)	12,690	$3,014	121,145	$82,336	476,678	$222,011
Arizona	(a)	(a)					(a)	(a)	(a)	(a)	17,268	5,799
Arkansas	(a)	(a)			(a)	(a)	361,824	94,176	17,646	11,677	582,053	176,923
California	605,131	$163,774			29,934	$10,491	1,029,062	125,391	1,605,649	637,015	3,781,388	1,138,128
Colorado	(a)	(a)			(a)	(a)			66,559	39,074	150,063	74,540
Connecticut									(a)	(a)	213,034	127,530
Delaware											166,413	101,252
Florida	(a)	(a)	(a)	(a)			(a)	(a)	23,966	8,131	262,971	145,579
Georgia	(a)	(a)							27,149	32,975	380,154	138,182
Hawaii					(a)	(a)			(a)	(a)	(a)	(a)
Idaho									(a)	(a)	(a)	(a)
Illinois	525,434	130,515			8,308	3,911	1,687,762	262,257	2,647,655	981,583	9,120,698	3,658,799
Indiana	424,575	130,482	(b)	(b)	c 47,992	c 11,853	1,663,277	216,994	1,795,165	669,529	5,906,196	1,591,158
Iowa	191,099	67,497	26,735	$8,616	48,052	12,798	471,822	119,223	878,918	444,522	2,909,441	1,060,586
Kansas	74,630	19,225					55,872	3,131	32,694	6,266	823,403	195,578
Kentucky	53,548	21,925			(a)	(a)	194,291	75,598	263,121	129,436	905,414	490,546
Louisiana	(a)	(a)			(a)	(a)	332,584	33,676	963,546	528,923	1,514,522	639,807
Maine									3,900	4,039	8,169	7,358
Maryland	148,721	63,515	(a)	(a)	(a)	(a)			782,614	470,751	1,727,440	923,463
Massachusetts	14,324	7,262	(a)	(a)	3,671	5,001	(a)	(a)	263,099	267,130	1,005,952	694,960
Michigan	136,214	49,669			94,227	41,267	207,827	21,829	2,292,374	1,011,182	3,814.445	1,641,748
Minnesota	78,211	24,761			90,355	32,758	23,969	3,164	433,382	246,966	1,209,455	488,069
Mississippi			(a)	(a)			764,792	116,299	577,696	216,409	1,414,048	360,664
Missouri	(a)	(a)			(a)	(a)	95,096	28,095	565,039	183,860	2,274,072	1,101,745
Montana	(a)	(a)					(a)	(a)	247,968	88,806	597,642	139,384
Nebraska	211,345	109,362	(a)	(a)	(a)	(a)	19,449	2,335	82,550	42,047	1,327,152	358,414
Nevada							38,810	2,906	18,518	4,001	75,466	8,813
New Hampshire							(a)	(a)	257,071	27,683	258,638	28,070
New Jersey	121,601	57,725	21,567	24,859	48,222	41,686			787,453	332,286	3,782,457	2,025,324
New Mexico									(a)	(a)	(a)	(a)
New York	65,423	34,271	2,325	1,356	52,853	21,032	(a)	(a)	2,353,100	1,141,947	7,119,013	3,046,447
North Carolina	16,829	7,834					(a)	(a)	111,149	69,714	543,364	231,813
North Dakota			(a)	(a)					4,090	3,125	5,750	4,425
Ohio	294,272	142,497	4,624	5,556	10,805	7,098	549,002	142,594	1,554,759	1,001,186	6,192,602	4,375,549

a Included in "Combined totals."

b A small output included in "Other sands."

c Includes a small output of "Filter sand."

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Sand and gravel produced in the United States in 1917 and 1918—Continued.

1917—Continued.

State.	Paving sand.		Filter sand.		Other sands.		Railroad ballast sand and gravel.		Gravel.		Total.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Oklahoma	(a)	(a)			(a)	(a)			177,372	$74,096	463,233	$244,432
Oregon	64,760	$47,475					315,258	$88,081	259,104	127,970	698,351	242,529
Pennsylvania	432,849	356,575	(a)	(a)	18,567	$19,199			1,721,480	988,879	6,254,635	5,283,000
Rhode Island											(a)	(a)
South Carolina	(a)	(a)	(a)	(a)			(a)	(a)	9,869	4,112	96,068	42,162
South Dakota	6,458	2,216			(a)	(a)	121,523	17,245	47,383	24,963	194,520	49,654
Tennessee	40,493	24,776			(a)	(a)	92,579	26,127	357,800	220,277	885,967	489,577
Texas	50,527	28,128			(a)	(a)	78,863	18,790	1,090,894	489,427	1,580,989	716,457
Utah	(a)	(a)			(a)	(a)	112,174	5,895	124,890	50,901	307,596	82,707
Vermont							(a)	(a)	6,076	501	51,827	40,624
Virginia	(a)	(a)			(a)	(a)	(a)	(a)	554,501	292,193	1,126,527	532,310
Washington	174,143	37,879			(a)	(a)	(a)	(a)	446,145	113,874	895,120	199,565
West Virginia	56,298	29,827			(a)	(a)			197,446	163,748	877,679	966,763
Wisconsin	161,333	65,045			616,460	194,268	486,582	67,181	1,434,804	489,735	3,609,869	1,080,860
Wyoming							(a)	(a)	(a)	(a)	(a)	(a)
Combined totals	400,256	165,234	6,769	$6,904	193,489	65,023	1,534,896	319,376	106,991	40,935	709,643	123,628
	4,348,474	1,789,469	62,170	47,351	1,262,785	376,415	10,260,999	1,743,377	25,312,820	11,764,812	76,419,225	35,296,932

a Included in "Combined totals."

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Sand and gravel produced in the United States in 1917 and 1918—Continued.

1918.

State.	Glass sand.		Molding sand.		Building sand.		Grinding and polishing sand.		Fire or furnace sand.		Engine sand.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Alabama			119,975	$47,037	230,481	$128,806			(a)	(a)	(a)	(a)
Arizona												
Arkansas	(a)	(a)	(a)	(a)	82,602	49,479	(a)	(a)			(a)	(a)
California	(a)	(a)	14,834	20,695	486,862	169,110			(a)	(a)	34,577	$7,911
Colorado			(a)	(a)	62,197	25,033			(a)	(a)	(a)	(a)
Connecticut			2,081	1,625	109,979	67,990	(a)	(a)				
Delaware			5,874	4,727	64,594	49,312					(a)	(a)
Florida			(a)	(a)	32,869	13,227	(a)	(a)				
Georgia	6,862	$6,864	35,001	12,705	187,171	75,253	(a)	(a)	(a)	(a)	15,121	3,800
Hawaii					(a)	(a)						
Idaho												
Illinois	760,835	1,273,804	885,617	658,205	1,832,195	756,888	46,450	$139,390	88,800	$58,925	107,041	31,589
Indiana	46,681	13,500	298,934	135,605	1,061,189	308,461	34,624	8,988			117,599	34,022
Iowa	(a)	(a)	29,219	13,469	903,425	391,120	6,926	2,761	(a)	(a)	33,283	14,748
Kansas					682,525	238,535					49,749	17,848
Kentucky	(a)	(a)	45,129	46,030	326,237	249,674	(a)	(a)	(a)	(a)	3,593	2,294
Louisiana	(a)	(a)			188,035	85,056	(a)	(a)			750	575
Maine					12,532	6,906					(a)	(a)
Maryland	(a)	(a)	(a)	(a)	795,848	395,155	(a)	(a)			38,384	61,065
Massachusetts	(a)	(a)	58,768	50,614	620,262	507,278	23,807	36,397	(a)	(a)	14,488	6,638
Michigan			116,485	55,255	433,497	174,888	(a)	(a)	(a)	(a)	5,174	1,322
Minnesota			14,614	14,790	291,196	149,809	(a)	(a)	8,359	1,610	13,470	6,729
Mississippi					113,043	58,115					12,140	4,642
Missouri	141,062	202,763	116,671	65,111	546,986	213,321	(a)	(a)	(a)	(a)	32,793	21,143
Montana					4,177	4,964						
Nebraska					773,049	204,657					14,912	2,181
Nevada	(a)	(a)									(a)	(a)
New Hampshire					2,525	934						
New Jersey	139,992	242,762	442,007	626,637	1,748,576	690,209	47,824	121,022	62,185	100,857	56,543	40,925
New Mexico					(a)	(a)						
New York			519,681	770,512	1,997,091	581,835			(a)	(a)	73,603	41,668
North Carolina			(a)	(a)	91,959	35,721					(a)	(a)
North Dakota												
Ohio	130,359	277,475	857,481	1,493,541	1,722,737	1,062,108	64,694	229,131	109,680	273,824	59,300	36,843
Oklahoma	(a)	(a)	(a)	(a)	232,692	111,235					(a)	(a)

a Included in "Combined totals."

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Sand and gravel produced in the United States in 1917 and 1918—Continued.

1918—Continued.

State.	Glass sand.		Molding sand.		Building sand.		Grinding and polishing sand.		Fire or furnace sand.		Engine sand.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Oregon			(a)	(a)	44,901	$36,125						
Pennsylvania	450,880	$1,065,162	1,158,715	$953,886	1,537,984	1,529,133	460,047	$881,799	143,932	$211,330	354,190	$543,453
Rhode Island												
South Carolina			(a)	(a)	55,434	34,648						
South Dakota					10,046	7,496						
Tennessee	(a)	(a)	33,016	18,688	494,540	333,573			(a)	(a)	33,221	17,454
Texas	(a)	(a)	(a)	(a)	221,285	105,227					25,622	8,729
Utah					(a)	(a)					(a)	(a)
Vermont			(a)	(a)	3,691	1,133	38,390	6,579				
Virginia	(a)	(a)	12,148	15,691	771,832	395,511	(a)	(a)	(a)	(a)	92,634	39,085
Washington					49,165	42,122					(a)	(a)
West Virginia	399,936	942,331	(a)	(a)	190,838	192,840	8,641	17,466	(a)	(a)	132,717	128,199
Wisconsin	(a)	(a)	107,782	90,658	615,584	251,870	(a)	(a)			59,893	7,254
Wyoming					(a)	(a)					(a)	(a)
Combined totals	96,280	185,067	36,146	26,384	55,054	37,799	243,862	115,529	59,777	54,854	81,668	29,944
	2,172,887	4,209,728	4,910,178	5,121,865	19,686,885	9,772,556	975,265	1,559,062	472,733	701,400	1,462,465	1,110,061

a Included in "Combined totals."

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Sand and gravel produced in the United States in 1917 and 1918—Continued.

1918—Continued.

State.	Paving sand.		Filter sand.		Other sands.		Railroad ballast sand and gravel.		Gravel.		Total.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Alabama	(a)	(a)	2,978	$3,585			165,131	$82,980	149,278	$122,953	712,787	$406,933
Arizona	(a)	(a)					(a)	(a)			3,722	5,920
Arkansas	(a)	(a)					105,484	7,118	18,513	21,192	230,239	107,290
California	457,255	$134,724			11,501	$2,007	563,117	116,879	1,431,647	589,766	3,011,842	1,070,441
Colorado	(a)	(a)					24,265	4,282	65,412	50,056	172,472	90,657
Connecticut	(a)	(a)							(a)	(a)	140,383	99,233
Delaware	13,440	8,839	794	397					(a)	(a)	103,299	76,822
Florida	(a)	(a)	(a)	(a)			(a)	(a)	(a)	(a)	158,489	48,768
Georgia	(a)	(a)							18,500	19,900	270,071	121,655
Hawaii											(a)	(a)
Idaho									(a)	(a)	(a)	(a)
Illinois	54,925	39,937	72	360	23,233	20,772	914,418	255,675	1,641,820	744,579	6,355,406	3,980,124
Indiana	195,344	62,091	150	110	95,002	23,798	1,382,741	362,604	1,553,351	770,238	4,785,615	1,719,417
Iowa	62,577	30,202	10,686	5,649	33,357	11,277	397,795	71,356	524,541	361,200	2,004,444	904,307
Kansas	(a)	(a)							(a)	(a)	761,110	264,073
Kentucky							142,978	24,861	284,261	203,188	818,471	557,548
Louisiana	(a)	(a)	200	80	(a)	(a)	41,964	13,600	788,068	493,776	1,024,498	595,682
Maine							1,740	895	21,051	23,320	35,623	31,421
Maryland	(a)	(a)			(a)	(a)	(a)	(a)	876,964	768,182	1,759,419	1,303,780
Massachusetts	54,263	24,665	2,445	3,535	42,485	30,139	3,451	1,804	346,661	455,830	1,170,562	1,133,884
Michigan	237,317	89,430			6,163	3,048	161,552	18,314	1,741,681	869,316	2,837,371	1,239,874
Minnesota	5,350	4,700	(a)	(a)	(a)	(a)	263,087	22,873	355,851	232,097	1,150,660	492,232
Mississippi			135	75			681,508	93,135	392,689	190,686	1,199,515	346,653
Missouri					(a)	(a)	359,404	46,639	439,281	138,562	1,743,616	772,753
Montana					(a)	(a)	331,280	54,394	12,140	14,616	348,347	74,474
Nebraska	50,587	16,537			4,939	689	54,054	8,005	77,777	46,569	975,318	278,638
Nevada							6,714	1,048	(a)	(a)	25,325	3,943
New Hampshire	2,468	749					916	471	117,834	14,849	123,743	17,003
New Jersey	180,280	104,976	13,859	37,399	(a)	(a)	(a)	(a)	880,746	493,720	3,579,862	2,462,864
New Mexico									(a)	(a)	(a)	(a)
New York	131,276	77,170	(a)	(a)	52,335	26,738	(a)	(a)	1,386,092	673,448	4,172,733	2,176,472
North Carolina	(a)	(a)					(a)	(a)	250,418	128,415	458,578	209,553
North Dakota									(a)	(a)	(a)	(a)

a Included in "Combined totals."

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Sand and gravel produced in the United States in 1917 and 1918—Continued.

1918—Continued.

State.	Glass sand.		Molding sand.		Building sand.		Grinding and polishing sand.		Fire or furnace sand.		Engine sand.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Oregon			(a)	(a)	44,901	$36,125						
Pennsylvania	450,880	$1,065,162	1,158,715	$953,886	1,537,984	1,529,133	460,047	$881,799	143,932	$211,330	354,190	$543,453
Rhode Island												
South Carolina			(a)	(a)	55,434	34,648						
South Dakota					10,046	7,496						
Tennessee	(a)	(a)	33,016	18,688	494,540	333,573			(a)	(a)	33,221	17,454
Texas	(a)	(a)	(a)	(a)	221,285	105,227					25,622	8,729
Utah					(a)	(a)					(a)	(a)
Vermont			(a)	(a)	3,691	1,133	38,390	6,579				
Virginia	(a)	(a)	12,148	15,691	771,832	395,511	(a)	(a)	(a)	(a)	92,634	39,085
Washington					49,165	42,122					(a)	(a)
West Virginia	399,936	942,331	(a)	(a)	190,838	192,840	8,641	17,466	(a)	(a)	132,717	128,199
Wisconsin	(a)	(a)	107,782	90,658	615,584	251,870	(a)	(a)			59,893	7,254
Wyoming					(a)	(a)					(a)	(a)
Combined totals	96,280	185,067	36,146	26,384	55,054	37,799	243,862	115,529	59,777	54,854	81,668	29,944
	2,172,887	4,209,728	4,910,178	5,121,865	19,686,885	9,772,556	975,265	1,559,062	472,733	701,400	1,462,465	1,110,061

a Included in "Combined totals."

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Sand and gravel produced in the United States in 1917 and 1918—Continued.

1918—Continued.

State.	Paving sand.		Filter sand.		Other sands.		Railroad ballast sand and gravel.		Gravel.		Total.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Alabama	(a)	(a)	2,978	$3,585			165,131	$82,960	149,278	$122,953	712,787	$406,933
Arizona	(a)	(a)					(a)	(a)			3,722	5,920
Arkansas	(a)	(a)					105,484	7,118	18,513	21,192	230,239	107,290
California	457,255	$134,724			11,501	$2,007	563,117	116,879	1,431,647	589,766	3,011,842	1,070,441
Colorado	(a)	(a)					24,265	4,282	65,412	50,056	172,472	90,557
Connecticut	(a)	(a)							(a)	(a)	140,383	99,233
Delaware	13,440	8,839	794	397					(a)	(a)	103,299	76,822
Florida	(a)	(a)	(a)	(a)			(a)	(a)	(a)	(a)	158,489	48,768
Georgia	(a)	(a)							18,500	19,900	270,071	121,655
Hawaii											(a)	(a)
Idaho									(a)	(a)	(a)	(a)
Illinois	54,925	39,937	72	360	23,233	20,772	914,418	255,675	1,641,820	744,579	6,355,406	3,980,124
Indiana	195,344	62,091	150	110	95,002	23,798	1,382,741	362,604	1,553,351	770,238	4,785,615	1,719,417
Iowa	62,577	30,202	10,686	5,649	33,357	11,277	397,795	71,356	524,541	361,200	2,004,444	904,307
Kansas	(a)	(a)							(a)	(a)	761,110	264,073
Kentucky							142,978	24,361	284,261	203,188	818,471	557,548
Louisiana	(a)	(a)	200	80	(a)	(a)	41,964	13,600	788,068	493,776	1,024,498	595,682
Maine							1,740	895	21,051	23,320	35,623	31,421
Maryland	(a)	(a)			(a)	(a)	(a)	(a)	876,964	768,182	1,759,419	1,303,780
Massachusetts	54,263	24,665	2,445	3,535	42,485	30,139	3,451	1,804	346,661	455,330	1,170,562	1,133,884
Michigan	237,317	89,430			6,163	3,048	161,552	18,314	1,741,681	869,316	2,837,371	1,239,874
Minnesota	5,350	4,700	(a)	(a)	(a)	(a)	263,087	22,873	355,851	232,097	1,150,660	492,232
Mississippi			135	75			681,508	93,135	392,689	190,686	1,199,515	346,653
Missouri					(a)	(a)	359,404	46,639	439,281	138,562	1,743,616	772,753
Montana					(a)	(a)	331,280	54,394	12,140	14,616	348,347	74,474
Nebraska	50,587	16,537			4,939	689	54,054	8,005	77,777	46,569	975,318	278,638
Nevada							6,714	1,048	(a)	(a)	25,325	3,943
New Hampshire	2,468	749					916	471	117,834	14,849	123,743	17,003
New Jersey	180,280	104,976	13,859	37,399	(a)	(a)	(a)	(a)	880,746	493,720	3,579,862	2,462,864
New Mexico									(a)	(a)	(a)	(a)
New York	131,276	77,170	(a)	(a)	52,335	26,738	(a)	(a)	1,386,092	673,448	4,172,733	2,176,472
North Carolina	(a)	(a)					(a)	(a)	250,418	128,415	458,578	209,553
North Dakota									(a)	(a)	(a)	(a)

a Included in "Combined totals."

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Sand and gravel produced in the United States in 1917 and 1918—Continued.

1918—Continued.

State.	Paving sand.		Filter sand.		Other sands.		Railroad ballast sand and gravel.		Gravel.		Total.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Ohio	326,281	$183,565	1,183	$2,957	47,430	$30,723	1,148,286	$323,291	1,533,809	$1,026,146	6,001,240	$4,939,604
Oklahoma					(a)	(a)	(a)	(a)	85,276	39,745	383,747	215,862
Oregon	50,047	26,640			(a)	(a)	81,316	16,408	297,151	113,954	473,745	193,559
Pennsylvania	348,039	406,932			76,050	77,658			1,772,840	1,538,487	6,302,677	7,207,840
Rhode Island									(a)	(a)	(a)	(a)
South Carolina	(a)	(a)	1,000	800	140	70			4,627	3,016	76,297	49,374
South Dakota	3,769	1,982					181,619	17,347	34,353	21,537	229,787	48,362
Tennessee	(a)	(a)			(a)	(a)	39,935	16,719	377,425	246,299	986,801	639,373
Texas	(a)	(a)	(a)	(a)			322,176	90,398	568,705	288,679	1,175,426	519,446
Utah	(a)	(a)			(a)	(a)	20,054	1,660	98,480	61,063	184,719	103,873
Vermont	(a)	(a)					104	54	726	280	47,059	10,462
Virginia	(a)	(a)			(a)	(a)	(a)	(a)	389,635	276,312	1,331,123	764,618
Washington	251,292	96,716					172,342	14,606	434,428	177,932	908,102	332,141
West Virginia	40,222	29,824							124,309	117,811	904,148	1,438,887
Wisconsin	121,142	56,738			34,660	18,345	229,977	22,910	1,000,961	361,967	2,170,312	809,884
Wyoming							3,000	200	495,976	48,888	502,746	50,293
Combined totals	136,270	63,908	17,609	20,030	238,857	108,531	284,097	81,711	46,824	42,499	12,977	11,087
	2,722,144	1,460,325	51,111	74,977	666,152	353,795	8,064,505	1,772,237	20,640,101	11,791,073	61,824,426	37,927,079

a Included in "Combined totals."

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IMPORTS.

There was no record of the quantity of sand imported into the United States between January and June, 1918, although the value is said to have been $44,555; but the imports during the last half of the year amounted to 284,036 short tons, valued at $46,910, an average price of 16½ cents a short ton. The total value of the imports was therefore $91,465 in 1918, as compared with $142,586 in 1917.

The word "imported" is somewhat misleading as regards most of the sand covered by these figures, because some of it was carried as ship's ballast and much of it was building sand brought in from Canada to localities near the border. The importation of some special grades of molding sand, such as the French sand for making fine bronze castings and of refractory sands from England for lining certain iron furnaces, is due to the difficulty of making our foreign-born molders and foundrymen believe that the foreign sands with which they are familiar are no better than the American product.

EXPORTS.

No distinct record of the exports of sand and gravel was kept until 1916. In that year the Bureau of Foreign and Domestic Commerce prepared a table showing such exports, which, however, gave value only, not quantity and kind. The exports of sand have been negligible until recently, but there seems to have been a fair gain in 1918 in spite of the shortage of shipping.

The largest quantity of sand and gravel exported was that sent to Canada for use as building material. No information is at hand as to the kinds of sand and gravel sent to the other countries named in the following table:

Value of sand and gravel exported from the United States in 1917–1918.

Destination.	1917.	1918.
Canada	$415,699	$599,876
Mexico	16,892	3,741
Panama	33,941	2,721
Japan	5,951	2,674
England	7,136	2,300
Cuba	1,743	1,788
Newfoundland	1,039	930
Brazil	226	393
China	217	132
Argentina	6	.....
Other countries	11,401	4,859
	494,251	619,414

GLASS SAND.

PRODUCTION.

A total of 2,172,887 short tons of glass sand was produced in the United States in 1918, an increase of 12 per cent over the output in 1917, which was 1,942,675 short tons. The average price in 1918 was $1.94 a ton, an increase of 40 per cent over price in 1917, which was $1.38 a ton. These figures seem especially encouraging to the producers when it is further stated that the total value was

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$4,209,728 in 1918, as compared with $2,685,014 in 1917, an increase of $1,524,714, or 57 per cent.

Examination of the accompanying table showing the production of glass sand in the six principal producing States in 1917 and 1918 is interesting. In 1917 Illinois, Pennsylvania, West Virginia, Missouri, New Jersey, and Ohio produced 94 per cent of the entire output of glass sand in the United States, and in 1918 the same States produced 93 per cent. New Jersey had the largest increase in price per ton, 80 cents; Pennsylvania gained 76 cents; West Virginia 73 cents; the inland States—Ohio, Missouri, and Illinois gained 41, 39 and 36 cents, respectively. This difference in increased valuation is mainly attributable to freight differentials, for if the freight charges to a given point differ the producer who has the longer haul must lower his price in order to compete with the dealer who has the shorter haul.

The cost of production varies according to the method used. Most of the glass sand produced in Illinois, for example, is obtained by hydraulic mining; most of that produced in Pennsylvania and West Virginia is quarried and crushed. Pennsylvania, West Virginia, and Ohio, in the order named, have the largest number of glass factories,[1] because they have cheap and abundant natural gas for fuel. The producers of glass sand in Illinois and Missouri must sell their product at a low initial price to compete with producers in the other States named.

Glass sand produced in six leading States in 1917–1918.

State.	1917.			1918.		
	Quantity (short tons).	Value.	Average price per short ton.	Quantity (short tons).	Value.	Average price per short ton.
Illinois	607,186	$679,618	$1.12	760,835	$1,273,804	$1.67
Pennsylvania	462,972	742,815	1.60	450,880	1,065,162	2.36
West Virginia	347,640	562,693	1.62	399,936	942,331	2.35
Missouri	153,970	162,838	1.05	141,062	202,763	1.44
New Jersey	100,448	93,194	.93	139,992	242,762	1.73
Ohio	161,408	276,619	1.72	130,359	277,475	2.13

Glass sand produced in the United States, 1910–1918.

Year.	Quantity (short tons).	Value.	Average price per ton.
1910	1,461,089	$1,516,711	$1.04
1911	1,538,666	1,543,733	1.01
1912	1,465,386	1,430,471	.97
1913	1,791,800	1,895,991	1.06
1914	1,619,649	1,568,030	.97
1915	1,884,044	1,606,640	.85
1916	2,018,317	1,957,797	.97
1917	1,942,675	2,685,014	1.38
1918	2,172,887	4,209,728	1.94

[1] The glass industry, report on the cost of production of glass in the United States: U. S. Dept. Commerce Misc. Ser. 60, 430 pp., 1917. Sold by the Superintendent of Documents, Government Printing Office, Washington, D. C., price 35 cents.

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GLASS-SAND LOCALITIES.

The resources of the United States in sand suitable for making the more common kinds of glass are very great. Twenty States produced glass sand in 1918, and it occurs in other States in numerous localities.

Localities where glass sand was reported as produced in 1918.

Arkansas: Ruddella.
California: Ione and Lake Majella.
Georgia: Lumber City.
Illinois: Millington, Oregon, and Ottawa.
Indiana: Michigan City.
Iowa: Clayton.
Kentucky: Olive Hill.
Louisiana: Opelousas.
Maryland: Robinson.
Massachusetts: Cheshire.
Missouri: Crystal City, Klondike, Pacific, and Silica.
New Jersey: Cedarville, Millville, Pembryn, South Vineland, and Williamstown Junction.
New York: Cleveland.
Ohio: Austintown, Howard, Massillon, New Lexington, Silica, and Toboso.
Oklahoma: Hickory and Roff.
Pennsylvania: Daguscahonda, Derry, Dunbar, Falls Creek, Kennerdell, Lewistown, Mapleton, Ridgway, St. Marys, Torpedo, and Vineyard.
Tennessee: Lagrange.
Texas: Santa Anna.
Virginia: Mendota.
West Virginia: Berkeley Springs, Buckhannon, Independence, Sturgisson, Terra Alta (Holmes Station), and West Berkeley.

BUILDING SAND.

The output of building sand in 1918 amounted to 19,686,885 short tons, valued at $9,772,556. In 1917 the output was 5,688,102 tons more. In money value the production of 1917 exceeded that of 1918 by $65,132. The decrease in quantity was 22 per cent; the decrease in value was less than 1 per cent.

The Government used a considerable quantity of building sand at numerous army cantonments and also built a large number of more or less temporary offices for its war activities in the city of Washington, as well as large manufacturing plants at other points, in the construction of which large quantities of sand and gravel were used.

In consequence of the restrictions placed upon building for other than Government or war industrial uses, there was a decided decrease in the commercial use of building materials of all kinds. To meet the natural increased demands alone a vast amount of building should have been done in 1918. When normal conditions return the industry will doubtless show great activity.

More building sand was produced in the State of New York in 1918 than any other State, but its total output was very little more than half that of 1917. The output of nearly all the States declined, that of New Jersey alone most closely approaching its output in 1917.

The six leading States in the production of building sand in 1918 were New York, Illinois, New Jersey, Ohio, Pennsylvania, and Indiana, in the order named. These six States produced 50 per cent of the output of the country. There was a general though irregular increase in value, with Pennsylvania in the lead. Pennsylvania received an average of 33 cents a ton more than in 1917, whereas the

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price in Ohio advanced only 15 cents and in New York, where the greatest quantity was used, the price advanced only 4 cents.

Building sand produced in six leading States in 1917–18.

State.	1917			1918		
	Quantity (short tons).	Value.	Average price per ton.	Quantity (short tons).	Value.	Average price per ton.
New York	3,836,257	$975,512	$0.25	1,997,091	$581,885	$0.29
Illinois	2,592,774	932,455	.36	1,832,195	756,888	.41
New Jersey	1,818,275	545,437	.30	1,748,576	690,209	.39
Ohio	2,318,904	1,090,689	.47	1,722,737	1,062,108	.62
Pennsylvania	1,996,524	1,319,624	.66	1,537,984	1,529,133	.99
Indiana	1,556,922	410,988	.26	1,061,189	308,461	.29

MOLDING SAND.

During 1918 the steel mills of the country were busy on war orders and a large number of foundries of metals were working at top speed. For this probably more than for any other reason there was a good demand for molding sand. There was an increase of 5 per cent in the production of sand of this class over that of 1917, and the price per ton received averaged 13 per cent higher. The output was 4,910,178 short tons, valued at $5,121,865, as compared with 4,660,968 tons, valued at $4,303,809, in 1917.

Molding sand produced in the United States, 1910–1918.

Year.	Quantity (short tons).	Value.	Average price per ton.
1910	3,636,167	$2,431,254	$0.67
1911	3,376,717	2,132,469	.63
1912	4,485,380	2,718,726	.61
1913	3,563,583	2,230,217	.63
1914	2,751,209	1,756,383	.64
1915	3,585,746	2,123,303	.59
1916	4,662,649	3,219,839	.69
1917	4,660,968	4,303,809	.92
1918	4,910,178	5,121,865	1.04

The output of six States which produced 85 per cent of all the domestic molding sand dug in 1918 is given in the following table:

Molding sand produced in six leading States in 1917–18.

State.	1917			1918		
	Quantity (short tons).	Value.	Average price per ton.	Quantity (short tons).	Value.	Average price per ton.
Pennsylvania	640,450	$696,734	$1.09	1,158,715	$953,886	$0.82
Illinois	703,208	412,626	.59	885,617	658,205	.74
Ohio	999,974	1,218,217	1.22	857,481	1,493,541	1.74
New York	650,427	808,550	1.24	519,681	770,512	1.48
New Jersey	611,916	651,279	1.06	442,007	626,637	1.42
Indiana	287,483	111,732	.39	298,934	135,605	.45

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FILTER SAND.

Filter sand is clean silica sand in sorted sizes, used for beds in water-filtration plants and in small mechanical filters. A city water supply taken from a stream which may be polluted by organic matter or at times heavily charged with sediment is purified by passing it through a sand filter. As silica is insoluble in water, good filter sand, once installed, may be used a long time. In 1918 the output was 51,111 short tons, valued at $74,977, an average price of $1.47 a ton, as compared with 62,170 short tons, valued at $47,351, or 76 cents a ton, in 1917. This was an increase of 58 per cent in value of output and of 93 per cent in average price per ton.

RAILROAD BALLAST.

There was a considerable decrease in the use of sand and gravel for railroad ballast in 1918, although the value increased, in sympathy with prices in general, from 17 to 22 cents a short ton. This material is produced mainly by the users. The railroads that dig out their own ballast are requested by the Survey to give not only the quantity of their output, but its value, based upon market quotations. Certain producing railroads, however, have reported the actual cost of the work of production as the value of the ballast, so that the Survey's estimate of value per short ton of output is more likely to be under than over the market value.

OTHER SANDS.

Sands produced for other uses than those already mentioned are inconsiderable in volume yet are of considerable value, and are tabulated as "Other sands."

The man in the street might regard as a joke the statement that sand is used as an ingredient of some fertilizers; nevertheless, in 1918 New York and Pennsylvania reported that 31,110 short tons of sand, valued at $22,360, was used as filler for fertilizer.

Sand is used as bedding for stock cars. Indiana and Iowa sold 6,339 short tons, valued at $1,602, for this purpose. Shippers of livestock may well compare the cost of other forms of bedding with that of sand at the present average cost of only 25 cents a short ton.

A few tons of fine-grained high-grade silica sand is sold annually for use by blacksmiths in welding iron and soft steel. Sand for this purpose is put up in 25-pound sacks and so brings a high price per ton. Likewise, high-grade silica sand, because of its whiteness, is sold in 3 and 5 pound cartons for use in mechanical toys and thus retails at about $60 a ton.

Producers in New York State chronicle the fact that a considerable quantity of sand known as "grits" found ready sale to poultry raisers.

A few hundred tons of clean, even-grained, and high-grade silica sand from Ottawa, Ill., is sold annually in small individual lots for use as a standard in physical tests of other sands. When a testing laboratory determines the strength of a sand as a component of cement, for example, a test of Ottawa sand is made at the same time under similar conditions for comparison. Such a testing sand must

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be procurable with absolute uniformity of physical characteristics through a long period of years. Ottawa sand meets the requirements and is widely used for this purpose.

CALCULATION OF WEIGHTS, MEASURES, AND VALUES.

The unit used in this report for quantities of sand and gravel is the short ton, 2,000 pounds, but many dealers use the cubic yard in their computations and have been so reporting their outputs. Some standard of relation between the two units, however, is necessary, for without such a standard a producer who sells his output by the cubic yard might be getting less for his sand than a competitor who sells by the short ton. Several years ago the Geological Survey asked a large number of producers of sand and gravel to furnish estimates of the average weight of a cubic yard of sand. Some of these dealers made actual tests of the weight of a cubic yard of the sand they sold. The reports show that a cubic yard of sand weighs from 2,000 to 4,000 pounds, the variation being due to differences in mineral composition, moisture content, and packing. The gravels averaged more than the sands, the maximum being 4,200 and the minimum 2,200 pounds. An average of all the weights reported was found, and the result was that a cubic yard of sand is now regarded as weighing 2,665 pounds and a cubic yard of gravel as weighing 2,820 pounds.

In response to repeated requests from new producers as to the method of converting yards to tons a few examples are here worked out. A producer of molding sand, let us assume, got out 500 cubic yards during the year. To find the number of short tons he produced, he should multiply 500 by 2,665, which will give his output in pounds, and should then divide the product—1,332,500—by 2,000 to get the short tons. He would find that he had produced 666¼ short tons.

Possibly this same man sold his sand for $1.35 a cubic yard and is still wondering whether his price equaled that received by his competing neighbor who charged $1.04 a short ton. The competitor received $1.04 for 2,000 pounds of his molding sand. Multiplying 2,665 (the average weight of a cubic yard) by $1.04 and dividing the product by 2,000 gives $1.38½, which is the price the competitor received for an average cubic yard of sand, or 3½ cents more than the man who sold at $1.35 a cubic yard. It happens that $1.04 was the average price per short ton received for molding sand in 1918, and as this is about $1.38½ a cubic yard, some of the readers of this report may discover that they have received more or less than this average through difference in the method they used in selling.

A short method of reducing long tons to short tons is as follows: A long ton contains 2,240 pounds and is therefore 1.12 times as heavy as a short ton. A convenient rule to find the number of short tons is thus to multiply the number of long tons by 1.12.

The quantity of sand in any number of cubic yards may be reduced to weight in short tons by a similar method. It is, however, necessary that the weight in pounds per cubic yard be known. This, of course, varies in different pits. For sand weighing an average of 2,800 pounds a cubic yard, for example, divide 2,800 by 2,000, which

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gives 1.4; multiply this quotient by the number of cubic yards, and the product will be the number of short tons. The rule in this case would be: To find the number of short tons divide the weight in pounds of 1 cubic yard by 2,000 and multiply the quotient by the number of cubic yards.

CHATS AND CHERT.

The tables of production given above do not include a considerable quantity of chats or tailings from the Missouri zinc mines. This waste product, which is used on roads, has a nominal value equal to the cost of loading. The shipments of chats in 1918, as reported by the Missouri Bureau of Geology and Mines, amounted to 902,125 short tons, compared with 1,426,716 tons in 1917. Of these shipments in 1917, 1,055,972 tons were from mines in southwestern Missouri and 370,744 tons from mines in southeastern Missouri. More than 1,000,000 tons of this material is believed to have been used for railroad ballast, and the rest for other purposes, such as road metal and concrete.

Neither do the tables include more than 40,000 tons of chert dug in Alabama and valued at more than $17,000.

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FLUORSPAR AND CRYOLITE.

By Ernest F. Burchard.[1]

INTRODUCTION.

The period of intense activity in fluorspar mining, which began in 1917, continued unabated until shortly after the signing of the armistice on November 11, 1918. Noteworthy features of the fluorspar industry in 1918 were the continued strong demand, which is reported to have exceeded the supply at times, and the great increase in prices, which were the highest ever recorded. The high prices resulted in the discovery and exploitation of many hitherto unknown fluorspar deposits in the Western States, particularly in New Mexico, Colorado, and Utah. Utah became a shipper for the first time.

DOMESTIC FLUORSPAR MINED AND SHIPPED.

The total quantity of domestic fluorspar reported to the Survey as sold (shipped from mines) in 1918 was 263,817 short tons, valued at $5,465,481, compared with 218,828 tons, valued at $2,287,722, in 1917, an increase in quantity of 44,989 tons, or nearly 21 per cent, and in value of $3,177,759, or 139 per cent. The general average price per ton f. o. b. mines or shipping points for all grades of spar in 1918, according to these figures, was $20.72, compared with $10.45 in 1917, an increase of $10.27 a ton, or 98 per cent. The highest average selling price reported was in Kentucky and the lowest in Colorado. The selling price for much of the Colorado spar, particularly in the Jamestown district, represents the value of uncleaned crude spar at the mines. Before being marketed as a commercial product much of the crude material, including considerable so-called "lump" spar, has to be hauled to custom mills at Jamestown and Boulder and, after milling, the concentrates from the mill at Jamestown require a long haul to the railroad. Therefore prices to the consumer are very much higher than prices at the mines. Average prices in the Illinois-Kentucky district would have been higher had not some companies continued delivering spar on old contracts at prices between $5 and $10 a ton. On the other hand, extreme prices paid for spar for prompt delivery reached $38 to $45 a ton.

As usual, gravel spar, the grade used principally for flux in the manufacture of open-hearth steel, constituted the bulk of the output. The shipments of gravel spar in 1918 amounted to 236,121 short tons, valued at $4,735,260, compared with 183,144 tons, valued at $1,759,920, in 1917, an increase in quantity of 52,977 tons, or 29 per cent, and in total value of $2,975,340, or 169 per cent. The sales of lump

[1] The statistics of domestic fluorspar were compiled by Hubert W. Davis, and those of imports and exports were compiled by J. A. Dorsey, both of the United States Geological Survey.

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spar in 1918 were 18,944 short tons, valued at $457,018, compared with 25,548 tons, valued at $349,460, in 1917, a decrease in quantity of 6,604 tons, or 26 per cent, but an increase in value of $107,558, or 31 per cent. Ground spar was marketed in 1918 to the extent of 8,752 short tons, valued at $273,203, compared with 10,136 tons, valued at $178,342, in 1917, a decrease in quantity of 1,384 tons, or 14 per cent, but an increase in value of $94,861, or 53 per cent.

The total quantity of crude fluorspar mined can not be ascertained exactly, because at most of the smaller mines only the cleaned spar is weighed. From such figures as are available, however, it is apparent that the crude spar mined in 1918 amounted to 326,039 short tons, compared with 280,825 tons in 1917, an increase of 16 per cent. The quantity of merchantable spar mined in 1918 amounted to 270,412 short tons.

FLUORSPAR MINED AND SHIPPED, BY STATES.

Fluorspar was mined and shipped in 8 States in 1918—Illinois, Kentucky, Colorado, New Mexico, New Hampshire, Arizona, Utah, and Washington—compared with 5 States in 1917. The Illinois-Kentucky district produced a little more than 83 per cent of the entire output of the United States in 1918. The mines in Illinois produced nearly 60 per cent of the total output of the Kentucky-Illinois district and nearly 50 per cent of the total for the United States. Illinois and New Hampshire were the only States to show decreases in output in 1918. In Illinois this was caused by the flooding of the mines of one of the largest operators and the incompetency of the labor available in the district. Illinois, however, showed an increase in value of output of more than $1,513,000 in 1918, and Kentucky an increase of more than $1,371,000. Crittenden County, in western Kentucky, shipped 75,808 tons of flourspar in 1918, or about 74 per cent more than the shipments from the whole State in 1917. The mines in Livingston and Caldwell counties in western Kentucky and those adjacent to Nicholasville in central Kentucky also showed substantial increases in production. Tennessee has in earlier years produced fluorspar, and deposits are reported to have been discovered in other States, among which are California, Georgia, and Nevada. Small crystals have been observed in the joints of Ordovician limestone near Appleton, Wis. The discovery of a vein of flourspar near Low, Tooele County, Utah, was reported and a small quantity of spar was shipped from it. In Arizona spar was produced in Yavapai, Greenlee, and Pima counties for the first time, the output from this State heretofore having come mainly from the Castle Dome district, Yuma County, from which during recent years there has been little production. There was greatly increased activity in 1918 in the Jamestown district, Colorado, the shipments increasing from 2,326 short tons in 1917 to 22,810 tons in 1918, an increase of 20,484 tons, or 881 per cent. Most of the spar from this district is purchased by local companies that operate concentrating mills, in which the spar is raised in grade before being shipped to consumers. New Mexico, which had not produced any spar since 1915, contributed to the output in 1918.

Such details of the fluorspar shipments by States as may be published by the Survey without revealing statistics of individual producers are given in the following table for the years 1914 to 1918:

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Domestic fluorspar sold, 1914–1918.

State.	Gravel.			Lump.			Ground.			Total.		
	Quantity (short ton).	Value.	Average price per ton.	Quantity (short ton).	Value.	Average price per ton.	Quantity (short tons).	Value.	Average price per ton.	Quantity (short ton).	Value.	Average price per ton.
1914.												
Illinois	77,048	$397,913	$5.16	8,842	$74,708	$8.45	6,998	$82,428	$11.78	73,811	$426,063	$5.77
Kentucky										19,077	128,986	6.76
Other States[a]	[b] 2,228	[b] 14,992	6.73	(b)	(b)					2,228	14,992	6.73
	[b] 79,276	[b] 412,905	5.21	[b] 8,842	[b] 74,708	8.45	6,998	82,428	11.78	95,116	570,041	5.99
1915.												
Illinois	112,769	547,415	4.85	12,033	90,337	7.51	10,757	116,161	10.80	135,559	753,913	5.56
Kentucky												
Other States[a]	[b] 1,382	[b] 10,562	7.64	(b)	(b)					1,382	10,562	7.64
	[b] 114,151	[b] 557,977	4.89	[b] 12,033	[b] 90,337	7.51	10,757	116,161	10.80	136,941	764,475	5.58
1916.												
Illinois	123,983	660,714	5.33	14,489	114,993	7.94	7,595	94,039	12.38	146,067	869,746	5.95
Kentucky												
Other States[a]	[b] 9,668	[b] 52,908	5.47	(b)	(b)					9,668	52,908	5.47
	[b] 133,651	[b] 713,622	5.34	[b] 14,489	[b] 114,993	7.94	7,595	94,039	12.38	155,735	922,654	5.92
1917.												
Colorado	11,140	94,365	8.47	5,964	102,268	17.15				17,104	196,633	11.50
Illinois	136,954	1,111,348	8.11	19,584	247,192	12.62	10,136	178,342	17.59	156,676	1,373,333	8.77
Kentucky	33,641	534,017	15.87							43,639	697,566	15.98
Other States[a]	[b] 1,409	[b] 20,190	14.33	(b)	(b)					1,409	20,190	14.33
	[b] 183,144	[b] 1,759,920	9.61	[b] 25,548	[b] 349,460	13.68	10,136	178,342	17.59	218,828	2,287,722	10.45
1918.												
Arizona				364	5,537	15.21				364	5,537	15.21
Colorado	32,680	287,620	8.80	5,795	129,160	22.29				38,475	416,780	10.83
Illinois	122,721	2,565,394	20.90	9,518	260,948	27.42	8,752	273,203	31.22	132,798	2,887,099	21.74
Kentucky	79,411	1,856,739	23.38							87,604	2,069,185	23.62
New Mexico	[b] 1,309	[b] 25,507	19.49	[b] 3,267	[b] 61,373	18.79				3,437	64,348	18.72
Other States[a]										1,139	22,532	19.78
	[b] 236,121	[b] 4,735,260	20.05	[b] 13,944	[b] 457,018	24.12	8,752	273,203	31.22	263,817	5,465,481	20.72

[a] 1914: Colorado and New Hampshire; 1915: Colorado, New Hampshire, and New Mexico; 1916: Arizona, Colorado, and New Hampshire; 1917: Arizona and New Hampshire 1918: New Hampshire, Utah, and Washington.

[b] Some lump spar is included with gravel.

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In 1918 there were 119 operators who produced fluorspar, compared with 52 in 1917.

Merchantable fluorspar mined and number of producers in 1918, by States.

State.	Number of producers.	Quantity (short tons).	Percentage of total.
Illinois	13	134,039	49.57
Kentucky	54	90,900	33.61
Colorado	37	39,099	14.46
New Mexico	7	4,736	1.75
New Hampshire	2	[a] 1,029	a. 38
Arizona	4	539	.20
Utah	1	70	.03
Washington	1	(a)	(a)
	119	270,412	100.00

[a] Output of Washington included with New Hampshire.

In the following table, summarizing the annual output of domestic fluorspar from 1883 to 1918, the quantities from 1883 to 1905 represent quantity mined; beginning with 1906 they represent quantity shipped from mines. Subnormal conditions are shown in the pre-war year 1914, and more or less abnormal conditions in 1915 to 1918.

Fluorspar produced in the United States, 1883–1918.

Year.	Quantity (short tons.)	Value.	Year.	Quantity (short tons).	Value.	Year.	Quantity (short tons).	Value.
1883	4,000	$20,000	1896	6,500	$52,000	1909	50,742	$291,747
1884	4,000	20,000	1897	5,062	37,159	1910	69,427	430,196
1885	5,000	22,500	1898	7,675	63,050	1911	87,048	611,447
1886	5,000	22,000	1899	15,900	96,650	1912	116,545	769,163
1887	5,000	20,000	1900	18,450	94,500	1913	115,580	736,286
1888	6,000	30,000	1901	19,586	113,803	1914	95,116	570,041
1889	9,500	45,833	1902	48,018	271,832	1915	136,941	764,475
1890	8,250	55,328	1903	42,523	213,617	1916	155,735	922,654
1891	10,044	78,330	1904	36,452	234,755	1917	218,828	2,287,722
1892	12,250	89,000	1905	57,385	362,488	1918	263,817	5,465,481
1893	12,400	84,000	1906	40,796	244,025		1,789,341	15,704,924
1894	7,500	47,500	1907	49,486	287,342			
1895	4,000	24,000	1908	38,785	225,998			

Figure 57 shows graphically the course of the production of fluorspar in the United States from 1883 to 1918, the quantities beginning in 1906 representing shipments from mines. Two periods of fluctuation in output, between 1889 and 1898 and between 1902 and 1908, are in strong contrast with the large and steady increase in production in the periods 1898 to 1902 and 1908 to 1912. The decline from 1912 to 1914, although the greatest in actual tons, is not so great in proportion to the current production as that from 1905 to 1906, and the increase from 1914 to 1918 is clearly the largest in any similar period. For convenience in comparison the imports, beginning with the first full year for which records are available, 1910, are shown on the same diagram.

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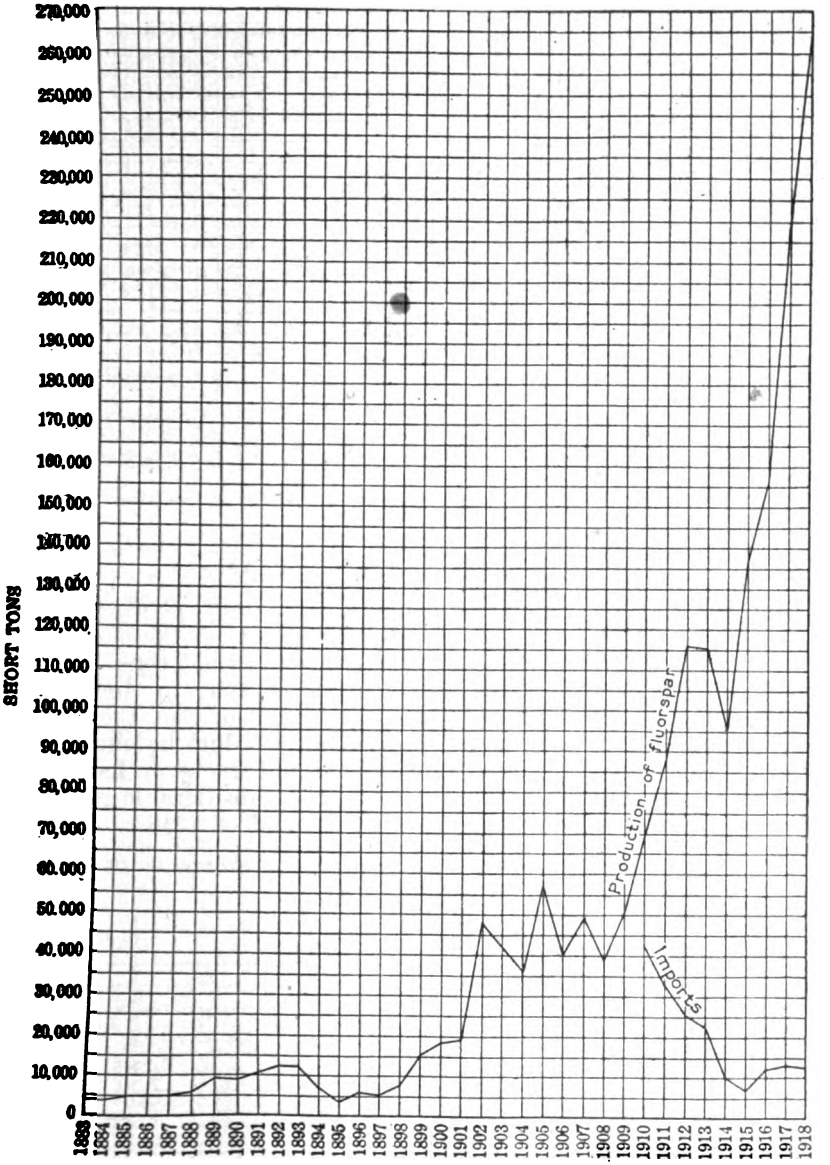

FIGURE 57.—Diagram showing production of fluorspar in the United States, 1883–1918, and imports, 1910–1918.

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Figure 58 shows the course of domestic fluorspar prices from 1883 to 1918.

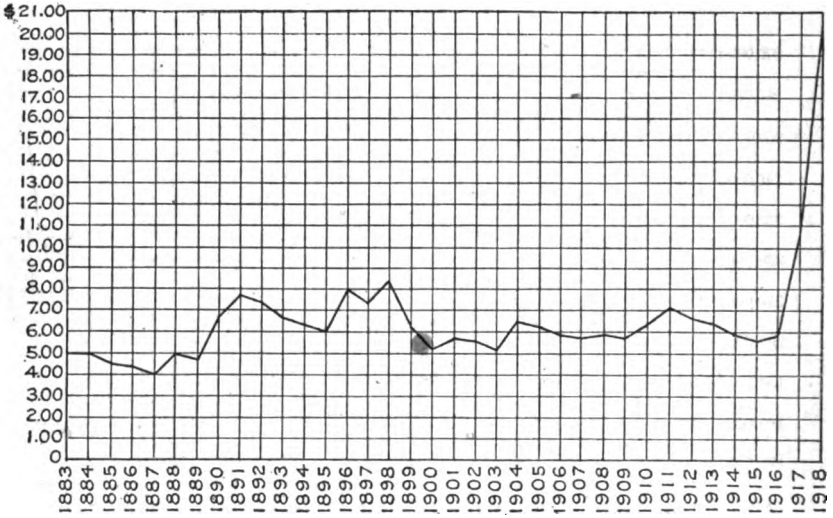

FIGURE 58.—Curve showing average prices per ton of fluorspar at the mines in the United States, 1883–1918.

STOCKS OF FLUORSPAR.

According to the reports of producers the total quantity of fluorspar in stock at the mines or at shipping points at the close of 1918 amounted to 22,779 short tons, compared with 21,655 tons in 1917, an increase of 5 per cent. As the quantity of spar in stock piles is necessarily partly estimated there are variations in the mine reports from year to year which prevent an absolute balance between the quantity mined and the quantity sold and stocks on hand. Data on consumers' stocks are not available, but considerable spar is understood to have been accumulated by the end of 1918.

Stocks of fluorspar at mines or shipping points, by States, in 1917 and 1918, in short tons.

State.	1917	1918
Arizona	88	255
Colorado	2,311	4,745
Illinois	5,024	5,288
Kentucky	13,942	10,942
New Hampshire	90	.....
New Mexico	.....	1,299
Utah	.....	50
Washington	200	200
	21,655	22,779

IMPORTS.

The imports of fluorspar into the United States entered for consumption in 1918 were 12,572 short tons, valued at $169,364, compared with 13,616 tons, valued at $114,598, in 1917. This represents a decrease in quantity of 1,044 tons, or 7.7 per cent, but an increase in total value of $54,766, or 48 per cent. The value at the foreign

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ports of shipment assigned to the imports in 1918 averaged $13.47 a ton, as compared with $8.42 in 1917, an increase of $5.05 a ton, or nearly 60 per cent. The imports of fluorspar in 1918 were equivalent to about 5.3 per cent of the domestic production of gravel spar, as compared with about 7.4 per cent in 1917. According to the values reported, including the duty of $1.50 a ton plus the ocean freight charges, the average cost of imported spar at the docks was $14.97 a ton in 1918, compared with $20.05 for domestic gravel spar at the mine or mills; in 1917 the cost of the imported material, including the duty of $1.50 a ton, was $9.92 a ton plus the ocean freight charges, compared with $9.61 for domestic gravel spar. Ocean freight charges are reported to range from $7.50 a ton, when material is carried as ballast, to $12 a ton otherwise.

The distances that domestic spar must be transported from mines to points where it is consumed are generally much greater than the distances that foreign spar must be carried from the docks to eastern steel plants, so that a slight advantage in price on account of a saving in railway freight charges may be enjoyed by the imported spar at eastern steel plants. Unless ocean freight rates are moderate, however, foreign spar is not in a position to enjoy much advantage in American markets. Foreign spar is not generally of so high grade as the mechanically treated spar from Illinois and Kentucky, and, as fluorspar is of value chiefly according to its purity, purchasers should find that the purer American spar is more efficient and consequently cheaper in the end. During the war difficulties in getting supplies of fluorspar from American mines when needed, on account of freight congestion, lack of cars, difficulties of transportation on Ohio River, and labor troubles, led steel manufacturers to accept readily whatever foreign spar was available. In 1918 England furnished 11,659 short tons, valued at $147,391, or $12.64 a ton at the British port of shipment and Canada supplied 913 short tons, valued at $21,973, or $24.07 a ton.

Fluorspar imported into the United States in 1918.

Source.	Port of entry.	Quantity (short tons).	Value.
England	Massachusetts	273	$3,617
	New York	1,235	19,824
	Philadelphia	3,626	47,251
	Maryland	6,525	76,699
		11,659	147,391
Canada	St. Lawrence	67	1,750
	Buffalo	446	10,033
	Dakota	39	637
	Michigan	361	9,553
		913	21,973
Grand total		12,572	169,364

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Fluorspar imported and entered for consumption, 1909–1918.[a]

	Quantity (short tons).	Value.	Average price per ton.
1909	6,971	$26,377	$3.78
1910	42,488	135,152	3.18
1911	32,764	80,592	2.46
1912	26,176	71,616	2.74
1913	22,682	71,463	3.15
1914	10,205	38,943	3.82
1915	7,167	22,878	3.19
1916	12,323	54,000	4.38
1917	13,616	114,598	8.42
1918	12,572	169,384	13.47

[a] Statistics compiled from records of Bureau of Foreign and Domestic Commerce, Department of Commerce.

CONSUMPTION.

The market for the bulk of the fluorspar sold in the United States depends on the condition of the steel industry, and the demand fluctuates with the rise and fall in the production of basic open-hearth steel. Most of the gravel and some of the lump spar are consumed as flux in basic open-hearth steel furnaces and to a smaller extent in other metallurgic operations. From 1914 to 1918 the sales of gravel spar have constituted between 83 and 90 per cent of the total marketed output of domestic fluorspar. Fluorspar is used also as a flux in iron blast furnaces, iron foundries, and in gold, silver, copper, and lead smelters; in the manufacture of fluorides of iron and manganese for steel fluxing and of sodium fluoride for wood preservation; in the manufacture of glass, enameled and sanitary ware, and of hydrofluoric acid; in the electrolytic refining of antimony and lead; and in the production of aluminum. Other miscellaneous uses of fluorspar that have been reported are as a bonding for constituents of emery wheels, for carbon electrodes, in the extraction of potash from feldspar, and in the recovery of potash in the manufacture of Portland cement.

A close estimate of the annual consumption of fluorspar in the United States can not be made without a knowledge of the stocks maintained by consumers. These stocks are variable, but were probably high at the end of 1918 at the plants of some of the largest consumers, because buying of spar during the year was heavy in anticipation of a possible future shortage, and after the signing of the armistice in Europe some spar not then needed was bought at reduced prices. Moreover, a very small quantity of domestic spar was reported to have been sold between January and May, 1919, although the output of open-hearth steel ingots for the four months January to April, 1919, was about the same as that for the corresponding period in 1918. The sales of domestic spar plus the imports (there are no considerable exports at present, and the figures are not listed separately by the Bureau of Foreign and Domestic Commerce) should give from year to year an index to the quantity entering into consumption and should indicate the relative increase or decrease in consumption. It is credibly reported that the consumption of fluorspar carrying 85 per cent of calcium fluoride averages about 11 pounds to 1 ton of basic open-hearth steel. In 1918 a total of 32,476,571 tons of basic open-hearth steel was manufactured, indi-

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cating a consumption of about 178,600 tons of gravel spar. The marketed production of gravel spar was 236,121 tons, thus indicating a surplus of about 57,500 tons in the hands of the consumers at the close of 1918. The total quantity of all grades of spar apparently consumed in 1918 was 276,389 short tons, as compared with 232,444 short tons in 1917, an increase of about 19 per cent.

The general relation between the consumption of fluorspar and the output of open-hearth steel may be noted by comparison of the following two tables:

Fluorspar available for consumption, 1910–1918, in short tons.

	Sales of domestic spar.	Imports for consumption.	Apparent consumption.
1910	69,427	42,488	111,915
1911	87,048	32,764	119,812
1912	116,545	26,176	142,721
1913	115,580	22,682	138,262
1914	95,116	10,205	105,321
1915	136,941	7,167	144,108
1916	155,735	12,323	168,058
1917	218,828	13,616	232,444
1918	263,817	12,572	276,389

Open-hearth steel produced in 1910–1918, in long tons.[a]

	Basic.	Acid.	Total.
1910	15,292,329	1,212,180	16,504,509
1911	14,685,932	912,718	15,598,650
1912	19,641,502	1,139,221	20,780,723
1913	20,344,626	1,255,305	21,599,931
1914	16,271,129	903,555	17,174,684
1915	22,308,725	1,370,377	23,679,102
1916	29,616,658	1,798,769	31,415,427
1917	32,087,507	2,061,386	34,148,893
1918	32,476,571	1,982,820	34,459,391

[a] Statistics for 1910 and 1911 according to annual reports of the American Iron and Steel Association and since 1911 from reports of American Iron and Steel Institute.

FLUORSPAR IN FOREIGN COUNTRIES.

CANADA.[1]

The production of fluorspar in Canada again shows a substantial increase. The principal production from Madoc, Ontario, was supplemented by shipments from a recently opened deposit in the Yale district, British Columbia.

The total shipments during 1918 were 7,362 short tons, valued at $135,712, as compared with 4,249 tons, valued at $68,756, in 1917.

Eight properties were operated in the Madoc district, and the average value of shipment was $18.15, as compared with $16.08 in 1917. Prices have varied with the grade of the product from $15 to $30 per ton. In addition to the Madoc occurrences, a small tonnage is reported to have been mined in the township of Cardiff.

The Consolidated Mining & Smelting Co. is operating the "Rock Candy" fluorspar deposit on Kennedy Creek, Kettle River, Yale, British Columbia. The company reports very favorable indications for a large tonnage in excess of their own requirements for export.

Canadian steel companies use from 10,000 tons to 15,000 tons per annum.

[1] Preliminary report of the mineral production of Canada during the calendar year 1918: Canada Dept. Mines, Mines Branch, 1919.

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GREAT BRITAIN.[1]

According to the official report[2] of output of mines and quarries issued by the Home Office at London, there were produced in Great Britain in 1917, the latest year for which statistics are available, 64,874 long tons of fluorspar, valued at $177,442, or $2.74 a ton, compared with 54,731 long tons, valued at $90,989, or $1.66 a ton, in 1916.

SWITZERLAND.[3]

Sembrancher, a small village on the Martigny-Orsières line (Valais), has just made itself conspicuous by the rediscovery of a lead stratum which had been worked in the sixteenth century and by the discovery of a precious mineral, the spath-fluor [fluorspar].

The mines are situated on the right bank of the Dranse, below Sembrancher, to the side of the Grand St. Bernard route and the railroad Martigny-Orsières. The stratum crosses the Mont-Chemin, and it is believed that there exist more strata parallel to the one just discovered.

In the principal mine, called the Trappist mine (from the time of Napoleon, when Trappist monks had taken refuge in the valley) the thickness of the stratum, mixed between layers of gneiss and schistoid porphyry, is of an average of 1 meter.

The principal mineral found is galena, composed in variable proportions of lead and argentiferous sulphur. The remainder is composed of a mineral easy to break, which was considered until now by geologists as baryta or quartz. But this is not the case and the mineral in question is spath-fluor or fluorina, almost pure, which, mixed with sulphuric acid, gives fluor-hydric acid, which has the property of attacking glass.

Until the present time Switzerland was tributary to abroad, and more especially to Thuringia (Germany), for the spath-fluor she needed.

PRODUCTION IN PRINCIPAL COUNTRIES.

The principal sources of the present world's supply of fluorspar are the United States, Great Britain, Germany, France, Austria-Hungary, Canada, Australia, and Spain, but the bulk of the world's supply comes from the United States and Great Britain, the former being also the chief consumer. In the following table is given the production of fluorspar in those of the above-mentioned countries for which statistics are available. No statistics are available for Germany and Austria-Hungary, but the annual pre-war output of these countries was about 20,000 tons and 8,000 tons, respectively.

Fluorspar produced in some principal countries, 1913–1918, in metric tons.

Country.	1913	1914	1915	1916	1917	1918
United States	104,853	86,289	126,954	141,282	198,519	239,333
Canada				1,165	3,855	6,679
Great Britain	54,522	34,357	33,653	55,607	65,912	(a)
Spain	351	79	370	277	250	(a)
France	7,524	(a)	(a)	(a)	(a)	(a)
Australia:						
New South Wales			417	1,385	1,605	(a)
Queensland					71	

a Statistics not available.

[1] For information on the fluorspar resources of Great Britain, see special report on fluorspar by the Geological Survey of Great Britain, 1916, and abstracts from this paper in the chapter on fluorspar in Mineral Resources for 1916, pt. 2, pp. 317–322, 1919.

[2] Mines and quarries, general report for 1917, pt. 3, 1918.

[3] Communication from Fletcher Dexter, United States vice consul, Lausanne, Switzerland, Mar. 4, 1919.

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OPTICAL FLUORSPAR.

Fluorspar suitable for optical purposes has occasionally been found in mines in southern Illinois, western Kentucky, and some Western States. During 1918, 371 ounces of optical fluorspar was produced from material mined in Riverside County, Calif., and Crittenden County, Ky. Several good specimens were received by the Survey during 1918.

Notes on the properties, uses, quality, and value of optical fluorspar and suggestions as to developments were given in the chapter on fluorspar in Mineral Resources for 1917, Part II, pages 301–302, in the chapter on gems and precious stones in Mineral Resources for 1918, Part II, page 13, and in Bulletin 38 of the Illinois Geological Survey, 1918.

FLUORSPAR IN RELATION TO THE WAR.

A special paper on fluorspar as a war mineral was issued by the Geological Survey two years ago.[1] That paper discussed the character and occurrence of fluorspar, its preparation and uses, the trend of the industry preceding and during the first three years of the European war, and the available domestic supplies of the mineral.

As the war was practically terminated in 1918, it is now of interest to summarize the part played by fluorspar during the whole of the war period, but the reader is referred to Bulletin 666 for many details for which there is not space here.

Principal war uses.—Fluorspar found its principal applications in war, as in peace, in the metallurgic, ceramic, and chemical industries, but the greatly increased demand for certain products of these industries led to a phenomenal growth in the consumption of this useful mineral. The number of ways in which it is utilized was also enlarged. In the metallurgic field 70 to 80 per cent of the output of fluorspar is used as a flux in the manufacture of basic open-hearth steel. The production of open-hearth steel increased more than 100 per cent from 1914 to 1918. Fluorspar is also finding considerable use as a flux in the manufacture of ferroalloys in the electric furnace. The output of electrically produced ferroalloys, including ferromaganese, spiegeleisen, ferrochromium, ferrosilicon, ferrotungsten, ferrovanadium, ferrotitanium, and ferromolybdenum, increased more than 3,000 per cent from 1914 to 1918. A special use for flourspar that was developed during the war was in the recovery of by-product potash from Portland cement kilns. A demand that was only partly supplied arose for clear, flawless crystals of fluorspar for use in the lenses of optical instruments.

Domestic supplies.—Domestic deposits of fluorspar were heavily drawn upon during the war, but they proved adequate to supply the demand. Imported spar, however, was readily sold whenever it became available, and it was needed at times to relieve shortages caused by difficulties in mining and transportation. High prices stimulated exploration for new deposits; many were discovered in the Western States and some in Kentucky and Illinois, and

[1] Burchard, E. F., Our mineral supplies—Fluorspar: U. S. Geol. Survey Bull. 666–CC, Oct. 2, 1917.

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there were new developments of hitherto unworked deposits in most of the producing States. The number of producers of fluorspar increased from approximately 19 in 1914 to about 119 in 1918. Continuous increase in output and in consumption of fluorspar during the war years is shown in the tables and curve. The output of 263,817 short tons in 1918 shows an increase of 177 per cent over the output of 1914, which was 95,116 tons, and the apparent consumption during the same period showed an increase from 105,321 tons in 1914 to 276,389 tons in 1918, or 162 per cent. Imports have remained nearly stationary, the annual average for the five war years having been about 11,000 short tons, compared with about 31,000 short tons for the years 1910 to 1913, prior to which records are not available.

The initiative in speeding up production of fluorspar in response to the demands of war was taken entirely by private interests. Government encouragement was not necessary beyond placing fluorspar mining in a preferred class in 1918 in order to assist the industry to hold at least a part of the labor necessary to the operation of the mines. Labor conditions, however, were far from satisfactory, for sufficient miners were not available and most of those who could be employed were inexperienced.

It was pointed out in Bulletin 666 that the fluorspar deposits in Illinois and Kentucky could be depended upon to supply for many years a demand much greater than normal and that other States possessed deposits that might be drawn upon to supplement the supply from the larger deposits for a considerable period. It was also stated that if demand should ever greatly exceed the supply from present domestic sources a considerable quantity of spar might be obtained by saving the concentrates at metalliferous mines. This procedure evidently did not become necessary, but it should be considered in connection with future economies, as the use of fluorspar in western smelting plants is very likely to increase.

CRYOLITE.[1]

The entire supply of natural cryolite used in the United States is imported from Greenland. Some artificial cryolite is understood to be produced in the manufacture of aluminum, but it is not reported as marketed commercially, and no statistics are available as to its output.

The quantity of cryolite reported to have been imported for consumption in the United States in 1918 was 1,950 long tons, valued at $97,500, compared with 4,383 tons, valued at $218,500, in 1917. The average value per ton at the Greenland port of shipment was $50 in 1918, compared with $49.86 in 1917. Cryolite is imported free of duty.

[1] Data on the character, source, mining, and use of cryolite are given in a paper by C. P. Bernard, entitled "The cryolite mine at Ivigtut, Greenland" (Min. Mag., London, April, 1916, pp. 202–203); also in the chapter on fluorspar and cryolite in U. S. Geol. Survey Mineral Resources, 1916, pt. 2, pp. 322–323, 1919.

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The annual imports of cryolite, beginning in 1894, as compiled from the records of the Bureau of Foreign and Domestic Commerce, are shown in the following table:

Cryolite imported and entered for consumption in the United States, 1894–1918.

Year.	Quantity (long tons).	Value.	Average price per ton.	Year.	Quantity (long tons).	Value.	Average price per ton.
1894 [a]	12,756	$170,215	$13.34	1907	1,438	$28,902	$20.10
1895	8,685	116,273	13.39	1908	1,124	16,445	14.63
1896	7,024	93,198	13.27	1909	1,278	18,427	14.42
1897	3,009	40,056	13.31	1910	36	2,343	65.08
1898	10,788	114,178	10.58	1911	2,007	47,003	23.46
1899	5,529	79,455	14.37	1912	2,126	48,293	22.72
1900	5,878	78,658	13.38	1913	2,559	52,557	20.54
1901	6,167	82,533	13.38	1914	4,612	94,424	20.47
1902	4,653	61,116	13.13	1915	3,940	82,750	21.00
1903 [b]	7,708	102,879	13.34	1916	3,857	165,222	42.84
1904	959	13,708	14.29	1917	4,383	218,500	49.86
1905	1,600	22,482	14.05	1918	1,950	97,500	50.00
1906	1,505	29,583	19.66				

[a] Fiscal years, 1894–1902. [b] Calendar years, 1903–1918.

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PEAT.

By C. C. Osbon.

INTRODUCTION.

The progress of the domestic peat industry since it attained commercial proportions in 1908 constitutes an interesting phase of the development of our mineral resources. Though extensively used as fuel in Europe and widely known in the United States as a potential source of heat and power, peat has been unable in most parts of this country to compete with coal, and consequently many peat operators have directed their attention to the uses of peat in agriculture, with the gratifying results recorded in this report. Peat fertilizer first entered the markets in commercial quantities in 1908 and stock-food peat in 1912, and though there is still some prejudice against the use of these products the agricultural branch of the peat industry has been successful and the quantity of fertilizer and stock-food peat annually produced is increasing. In 1918 peat fuel for the first time since 1914 entered the market in commercial quantity.

The notable increase in the output of peat in recent years, and especially in 1917 and 1918, is ascribed to the shortage and high price of coal and nitrates, to the nation-wide demand for increased production of food, to a better understanding of the nature of peat, and to the application of bacteriology to the cultivation of crops. It is believed that these conditions, though in part created by the war, will in large measure continue to exist in this country, that the demand for peat products will correspondingly increase, and that peat will maintain and even better the position it has taken in 1918 in the industrial progress of the United States.

PEAT INDUSTRY.

GENERAL CONDITIONS.

The greatest activity and expansion in the history of the domestic peat industry took place in 1918. The output of crude peat far exceeded the quantity produced in any preceding year, and nearly all branches of the industry shared in the increase. Large quantities of fertilizer and stock food were manufactured from peat, but the most striking development of the year was the production of more peat fuel in New England than has been manufactured commercially in the entire United States in all preceding years. Almost equally striking were the large quantity of peat moss produced and the widespread interest manifested in our peat resources, which had heretofore been popularly regarded as of little value.

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The total number of plants at which peat was commercially produced in 1918 was 25, an increase of 7 over the number operating in 1917. All the plants that operated in 1917 except four contributed to the output of peat in 1918, and 11 that were not represented in 1917 reported commercial production. Many new companies were organized in 1918, but did not complete their preliminary work in time to contribute to the year's output. Some stated that they could not obtain necessary machinery, but it seems that this situation has improved. As illustrated by Plate III, the plants known to be operating in 1918 were distributed as follows: California, 2; Connecticut, 1; Florida, 1; Georgia, 2; Illinois, 2; Indiana, 2; Maine, 1; Massachusetts, 3; New Hampshire, 1; New Jersey, 4; New York, 4; North Carolina, 1; and Pennsylvania, 1. Peat moss was also gathered by hand in Washington, Oregon, and Maine.

Nearly all producers reported that the demand for peat exceeded the supply, and it was stated by some that on account of meager facilities they were unable to fill the orders of their regular customers.

Many peat plants that operated in 1918 made improvements in order to increase production in 1919.

PRODUCTION.

CRUDE PEAT.

The quantity of crude air-dried peat produced in the United States in 1918 was 151,521 short tons—54,158 tons, or nearly 56 per cent, more than the record output of 97,363 tons in 1917.

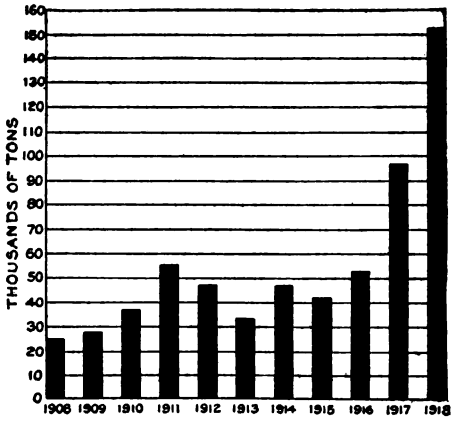

FIGURE 59.—Diagram showing development of the domestic peat industry, 1908–1918.

Nearly all producers of crude peat in this country use their entire output in the manufacture of peat products, and it was therefore impossible to determine accurately the value of the raw material. However, the average price received for all peat products in 1918 was $9.76 a ton, and the gross market value was $1,047,243, a gain of $2.47 in average price per ton and of $337,343, or approximately 48 per cent, in gross market value compared with 1917.

The accompanying tables and figure 59 show that the output of crude air-dried peat has materially increased in recent years.

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Crude air-dried peat produced in the United States, 1908–1918.

Year.	Quantity (short tons).	Year.	Quantity (short tons).
1908	a 24,800	1914	47,098
1909	29,167	1915	42,284
1910	37,024	1916	52,506
1911	55,143	1917	97,363
1912	47,380	1918	151,521
1913	33,260		

a Estimated.

Crude air-dried peat produced in the United States in 1918, by States.

State.	Quantity (short tons).	State.	Quantity (short tons).
Massachusetts	18,500	New York	3,501
New Jersey	70,228	Other States a	59,292
			151,521

a Includes California, Connecticut, Florida, Georgia, Illinois, Indiana, Maine, New Hampshire, North Carolina, and Pennsylvania.

PEAT PRODUCTS.

FERTILIZER.

The largest and most successful branch of the peat industry is engaged in the production of peat for a direct fertilizer and for a nitrogenous ingredient of commercial fertilizers. Of the 25 plants that produced peat in 1918, 19 used air-dried peat in the manufacture of fertilizer, the quantity of peat utilized, as reported to the United States Geological Survey, being 79,573 short tons. Compared with the output in 1917 this quantity is less by 12,690 tons, or about 14 per cent, but it exceeds the quantity used in 1916 by 31,467 tons, or about 65 per cent.

The average price received for the peat in 1918 was $9.74 a ton, a gain of $2.60 a ton over the average price received in 1917. Though there was a slight decrease in output in 1918, the increase in price was sufficient to make the total market value of the production, amounting to $775,313, exceed the value of the output in 1917 by $116,813, or nearly 18 per cent.

Of the total quantity of peat used in manufacturing fertilizer in 1918, 7,356 tons, valued at $64,170, or about $8.72 per ton, was bacterized.

The increasing acreage of land tilled, the shortage and high price of commercial fertilizers, and the better understanding of the nature of peat, of crop adaptations, and of soil bacteriology in recent years warrant the prediction that the peat-fertilizer industry will soon reach a high position among the mineral and allied industries of the United States related to agriculture. Successful machinery for producing peat fertilizer is referred to on page 342 of this report.

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Air-dried peat used in manufacturing fertilizer in the United States, 1908–1918.

Year.	Quantity (short tons).	Average price per ton.	Value.	Year.	Quantity (short tons).	Average price per ton.	Value.
1908	23,000	$5.27	a$121,210	1914	37,729	$6.62	$249,899
1909	26,768	4.44	118,891	1915	38,304	6.75	258,447
1910	37,024	3.79	140,209	1916	48,106	7.00	336,004
1911	51,733	4.97	257,204	1917	92,263	7.14	658,500
1912	41,080	4.53	186,022	1918	79,573	9.74	775,313
1913	28,460	5.96	169,600				

a Estimated.

STOCK FOOD.

The quantity of peat used in manufacturing stock food in the United States in 1918 was 7,096 short tons, valued at $106,935, or an average price of $15.07 a ton. Compared with 1917, the output in 1918 was greater by 1,996 tons, or 39 per cent, and the value was greater by $55,535, or 108 per cent. Four peat producers manufactured stock food in Illinois and New York in 1918, compared with three in 1917.

Air-dried peat used in manufacturing stock food in the United States, 1912–1918.

Year.	Quantity (short tons).	Average price per ton.	Value.	Year.	Quantity (short tons).	Average price per ton.	Value.
1912	3,000	$6.00	$18,000	1916	4,300	$7.50	$32,250
1913	4,800	5.75	27,600	1917	5,100	10.08	51,400
1914	(a)	.....	(a)	1918	7,096	15.07	106,935
1915	3,980	7.56	30,090				

a Not available.

FUEL.

Several of the experimental peat-fuel plants in the New England States mentioned in the survey report for 1917[1] reached the stage of commercial production in 1918 and contributed 20,567 short tons of air-dried peat, valued at $164,745, or an average price of $8 a ton, to the country's fuel supply. Some hand-cut peat was produced by the owners of small bogs for home use, but this output is not included in the figures given. Though the output of peat fuel in 1918 was relatively small and was due largely to the coal shortage, it exceeded the quantity produced in all preceding years and indicates that the New England States, because of their cold climate, extensive manufacturing industries, large population, and the high cost of coal, offer promising possibilities for the development of a successful peat-fuel industry. Most of the producers in 1918 used the air-drying machine process. It is understood that peat fuel machinery, which was scarce in the United States in 1918, may now be readily obtained. A description of the methods of manufacturing peat fuel that have been most successful both in Europe and in this country is given in Bureau of Mines Bulletin 16.

[1] Osbon, C. C., Peat: U. S. Geol. Survey Mineral Resources, 1917, pt. 2, p. 260, 1918.

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Peat fuel produced in the United States, 1908–1918.

Year.	Quantity (short tons).	Average price per ton.	Value.	Year.	Quantity (short tons).	Average price per ton.	Value.
1908	900	$9.00	$8,100	1914	1,925	$3.40	$6,540
1909	1,145	3.62	4,145	1915			
1910				1916	(a)	(a)	(a)
1911	300	5.00	1,500	1917			
1912	1,300	3.46	4,500	1918	20,567	8.00	164,745
1913							

[a] Geological Survey not at liberty to publish figures.

OTHER PRODUCTS.

Large quantities of peat or sphagnum moss were produced and utilized in this country in 1918 for stable litter, packing material, and surgical dressings, and several hundred thousand acres of peat soils were also used for the growth of both general and truck crops. It is understood that the stable litter was produced by the owners of small bogs for their own use, but that the packing material was sold to florists and nurserymen. According to J. W. Hotson,[1] under whose direction peat moss was collected in the Northwestern States for surgical use, 595,540 peat moss pads were prepared from October, 1917, to November 11, 1918, by the northwestern and Atlantic divisions of the American Red Cross. Most of the moss was gathered by volunteer labor from the bogs of Washington, Oregon, and Maine, and the pads were used in military hospitals both at home and abroad. At first the surgeons of the United States Army were not disposed to use the pads, but later the value of sphagnum was universally recognized. The gathering of moss and preparing of pads was largely curtailed when the armistice was signed, but it seems that the value of peat moss as an absorbent and disinfectant demonstrated during the war will not be forgotten and that it should be able to compete commercially with cotton for these purposes in normal times. A brief discussion of the best kinds of peat moss and of the method of gathering it is given in the report by Hotson.[1] As the quantity and value of the peat moss produced in 1918 and used for surgical dressings could not be ascertained, it is not included in the accompanying tables.

CONDITIONS IN PRINCIPAL STATES.

California.—Peat was produced by two companies in San Bernardino County, Calif., in 1918, and was used for the cultivation of citrus trees. One of these companies enriched its product by treatment with nitrifying bacteria. It is reported that treated peat, known locally as "humus," is gaining favor in the citrus industry of California and that two new peat plants were erected in 1918 but had not reached the stage of commercial production at the end of that year. No response was received to statistical inquiries directed to the Pacific Peat Fuel Co., San Francisco, Calif., mentioned by the Survey in 1917[2] as experimenting with the Herbein briqueting

[1] Hotson, J. W., Sphagnum from bog to bandages: Washington Univ. Puget Sound Biol. Sta. Pub., vol. 2, No. 17, pp. 213, 243, 1919.
[2] Osbon, C. C., Peat: U. S. Geol. Survey Mineral Resources, 1917, pt. 2, p. 260, 1918.

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process. Muck soils are used to a small extent in farming in California.

Connecticut.—Edward A. Beals, of Hartford, Conn., has made many energetic attempts to establish a peat industry in Connecticut, but although the State contains large deposits and plants have been erected, no market for peat fuel has thus far been created. Several years ago a peat plant was installed by the Connecticut Co., a subsidiary organization of the New York, New Haven & Hartford Railroad Co., at its Burrville power house, but after several trials the project was abandoned. A. N. Pierson, a florist of Cromwell, Conn., also attempted to substitute peat for coal in heating his greenhouses, but the raw peat selected contained an undue proportion of silica, which melted in the furnace and interfered with the draft. However, it is understood that a further effort is being made to produce peat fuel commercially in Connecticut, and it is hoped that the project will be successful.

Florida.—Two companies, one near Pablo Beach and the other at Citra, have manufactured peat fertilizer commercially in Florida for many years. In 1918, however, because of the shortage and high cost of labor, the former plant discontinued operations and the latter, operated by the Alphano Humus Co., of New York, N. Y., contributed the only peat that entered the markets from Florida in 1918. Prospective producers were hampered by inability to obtain necessary machinery. Reclaimed peat land is widely used by the agricultural industry of Florida.

Georgia.—Peat was produced in Georgia in 1918 by two plants located at Pineora and Tifton. The work was largely experimental, but it is said that the market for peat in Georgia is excellent, and that machinery is being installed in these plants to produce a large quantity of peat fertilizer in 1919.

Illinois.—As in previous years, two operators in Illinois contributed to the output of fertilizer and stock-food peat in 1918. One of them produces more stock-food peat than any other peat operator in the United States and is second in the production of fertilizer peat. Truck crops are extensively raised on the peat soils of Illinois, and tough peat-marsh grasses are harvested and used for the manufacture of rugs and for packing ice.

Indiana.—The contribution of Indiana to the peat industry of the United States in 1918 consisted of fertilizer peat produced from bogs near Fort Wayne and Lakeville by the Virginia-Carolina Chemical Co. and the St. Joseph Humus Co. The output of the former company was used in the manufacture of commercial fertilizer, but the latter's production was sold to florists and golf clubs and used as a direct fertilizer for potting plants and for use on lawns. The plant of the Virginia-Carolina Chemical Co., at Fort Wayne, Ind., was destroyed by fire in 1918. Large crops of celery, onions, and other truck crops are grown upon reclaimed peat land in Indiana.

Maine.—The output of peat in Maine in 1918 consisted of a small quantity of fuel produced by one operator near Lewiston, Androscoggin County, and sold locally. Others stated that they were awaiting the results of the experimental work of the Canadian

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Government at Alfred, Ontario, prior to erecting plants. A small quantity of peat moss was also gathered from the bogs of Maine in 1918 and used by the American Red Cross in the preparation of surgical dressings.

Massachusetts.—The output of air-dried peat in Massachusetts in 1918 amounted to 18,500 tons, valued at $160,200, and consisted of both fertilizer and fuel produced from bogs near Peabody, North Adams, and Shirley. One producer reported that some consumers were doubtful of the value of peat fuel; another stated that the demand exceeded the supply. It is understood that several companies were organized in 1918 but did not complete preliminary work in time to contribute to the State's output in that year. C. D. Jenkins, of Boston, has been one of the most active peat producers in Massachusetts for many years and has designed and patented peat-fuel machinery.

Michigan.—Although no peat was sold in Michigan in 1918, large-scale experimental work was done by Louis P. Haight, of Muskegon, who proposes to produce bacterized peat and use it in tilling sandy soil. A large peat-fertilizer plant was erected by the Fertile Chemical Co. at Chassell, Mich., in 1918. Though this company did not produce peat that year, it will probably contribute a substantial quantity of fertilizer to the output in 1919. To meet the demand for peat-fuel machinery in 1918 plans were designed and machinery was manufactured by the C. A. Willmarth Co. and J. Campbell Morrison, of Detroit, Mich., and by Herbert Garnett, of Grand Rapids, Mich.

Minnesota.—Although Minnesota contains almost half of the workable peat in the United States, no peat products were manufactured in that State in 1918. It is understood that the Hamm Brewery Co., of St. Paul, F. A. Wildes, the State superintendent of mines, and Henry W. Hindshaw, of Hibbing, experimented with peat in 1918. Attempts are being made to obtain funds from the State legislature for experimental work on peat in cooperation with the United States Bureau of Mines. A process was reported by Mr. Wildes by which peat, when mixed with fine iron ore and flue dust and burned, produces an ore of good texture. It is stated that the process will be tried on a large scale if funds can be obtained. Peat soils are extensively utilized in Minnesota for the cultivation of crops.

New Hampshire.—The contribution of New Hampshire to the output of peat products in 1918 consisted of a small quantity of peat moss gathered from a bog 25 acres in area and 10 feet deep, near Milford, Hillsboro County.

New Jersey.—The output of crude air-dried peat in New Jersey in 1918 amounted to 70,228 short tons, of which 26,213 tons, valued at $264,797, was used in the manufacture of fertilizer, and 44,010 tons, valued at $96,040, was placed in storage. Although peat is found in Bergen, Essex, Hudson, Mercer, Middlesex, Morris, Passaic, Somerset, Sussex, Union, and Warren counties, the entire output in 1918 was obtained by four producers from deposits in Sussex and Warren counties. More peat is produced in New Jersey than in any other State, and the largest producer is the Alphano Humus Co., of New York, N. Y. New Jersey supplies the New York mar-

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kets with large quantities of truck crops produced by the cultivation of peat soils.

New York.—Approximately 3,501 short tons of air-dried peat, valued at $49,430, was produced by four operators in Dutchess and Suffolk counties, N. Y., in 1918, and used largely for the manufacture of fertilizer. Many of the largest truck farms in New York consist chiefly of drained peat lands.

North Carolina.—The contribution of North Carolina to the peat industry consisted of a small output produced by one operator from a deposit 250 acres in extent near Newbern, Craven County, and sold to a company in Richmond, Va., for the manufacture of bacterized peat. It is understood that the deposit was purchased by the Richmond company in February, 1919.

Pennsylvania.—Pennsylvania contributed a small quantity of peat from a bog near Espy, Columbia County, in 1918.

Other States.—Oregon and Washington contributed the mass of the peat moss that was used by the American Red Cross in the preparation of surgical dressings in 1918. In addition to the States mentioned in which truck crops are raised on peat soil Iowa, Ohio, and Virginia contain large areas of reclaimed peat land that is used by farmers for trucking.

IMPORTS.

In previous years peat moss has been imported into this country from Canada, Germany, and Holland, but in 1918, because of the shortage of ships, no peat moss from foreign sources entered the country. The decline in imports since 1913 recorded in the following table was probably caused by the war, and it is believed that with the return of normal conditions the import trade of the moss industry will be resumed.

Peat moss imported for consumption in the United States, 1913–1918.

Year.	Quantity (short tons).	Average price per ton.	Value.	Year.	Quantity (short tons).	Average price per ton.	Value.
1913	10,963	$5.07	$55,719	1916	3,042	$9.16	$27,859
1914	9,921	5.80	57,542	1917	506	9.81	4,966
1915	7,514	6.41	48,142	1918			

EXPORTS.

No exports of crude peat or peat products were reported in 1918.

CONSUMPTION.

It is estimated that 107,261 short tons of crude air-dried peat was used in 1918 for the manufacture of fertilizer, stock feed, fuel, and other peat products, compared with 97,869 tons in 1917. As the crude peat and peat products were produced by the same operators no accurate value can be assigned to the raw material. The quantity of peat actually consumed in the United States is not susceptible of accurate determination on the basis of the statistics collected by the Geological Survey. However, as no peat is exported from this country, so far

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as can be ascertained, and as very little is held in storage, the sum of the quantity produced and the quantity imported provides an approximation of the quantity consumed that is not without value in the absence of more specific data.

Air-dried peat and peat moss used in the manufacture of peat products in the United States in 1917 and 1918.

Kind of product.	Sales.		Imports.		Total.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
1917.						
Fertilizer and fertilizer ingredient	92,263	$658,500	.....	.....	92,263	$658,500
Stock food	5,100	51,400	.....	.....	5,100	51,400
Moss	.....	.....	506	$4,966	506	4,966
	97,363	709,900	506	4,966	97,869	714,866
1918.						
Fertilizer and fertilizer ingredient	79,573	775,313	.....	.....	79,573	775,313
Stock food	7,096	106,935	.....	.....	7,096	106,935
Fuel	20,567	164,745	.....	.....	20,567	164,745
Miscellaneous	25	250	.....	.....	25	250
	107,261	1,047,243	.....	.....	107,261	1,047,243

STOCKS.

Approximately 44,260 short tons of crude aid-dried peat and peat products remained in storage in the United States at the end of 1918. In general peat products are marketed as quickly as possible, and hence only small quantities are kept in stock, but crude peat, because it can not be economically excavated and handled out of doors in wet or cold weather, must be produced during the air-drying season, which begins in April and ends in October. Sufficient raw material must therefore be produced in that period to supply peat-drying plants for about five months.

COMMERCIAL FACTORS.

A full discussion of the factors controlling the profitable utilization of a peat deposit is here given in order to indicate the causes of past failure. Some attempts made in this country to produce peat on a commercial scale have not been successful, but the failures appear to have been due not to a lack of a market for the product, but to the lack of sufficient capital, to the inexperience of operators, and to the injudicious choice of deposits, plant sites, manufacturing processes, and machinery. All these factors should be carefully considered by prospective producers.

LOCATION.

The location of the deposit is the prime factor in the successful operation of a peat plant. Many deposits containing peat suitable for commercial use are known in all the peat areas, but under present conditions in the United States only deposits located near the

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markets and where cheap labor and transportation may be obtained can be profitably developed. Thus the conditions for producing peat fuel successfully are most favorable in Minnesota, Wisconsin, northern Michigan, and the New England States, regions which contain no known coal fields and which, because of their cold climate and extensive manufacturing industries, consume large quantities of fuel. In the southern part of the Atlantic coastal region there are likewise no local sources of other mineral fuels, but the climate is mild and the demand for fuel relatively light compared with that in the Northern States. (See Pl. III.) Peat fertilizer plants should preferably, of course, be located near the agricultural districts and the largest commercial fertilizer plants. As peat is not well known in this country, a market will have to be created in many places, but if high-grade products can be sold at a low price it should be possible to build up successful industries.

QUANTITY AND QUALITY.

The prospective deposit should be carefully surveyed to ascertain whether it contains a sufficient quantity of good peat before plans are made for the erection of a plant. Typical samples should be analyzed to ascertain whether the peat is of suitable quality for the purpose desired. One of the great handicaps of the peat industry has been the lack of uniformly good quality, and, as the success of a plant depends upon the kind of raw material used, due care should be observed in its selection.

The requisite size of the deposit will, of course, vary with the capacity of the plant erected, but it is generally unwise to erect a plant on a deposit less than 100 acres in area and 4 feet in depth. The average peat deposit will yield approximately 200 tons of air-dried peat to the acre-foot. The product obtained by multiplying the area in acres by the depth in feet by 200 gives the approximate tonnage of peat in a deposit. The topographic maps issued by the United States Geological Survey show many important peat deposits in this country as swamps and marshes, the area of which may be readily estimated from the map. The dimensions of deposits that have not been mapped should be carefully measured. Although peat deposits less than 4 feet deep may be advantageously used for the growth of crops, they are of little value as a source of fertilizer or fuel. Numerous depth tests should therefore be made and the average thickness of the peat determined. An earth auger may be employed for this purpose, but a sampling tool especially designed by the late C. A. Davis[1] for testing the depth of peat deposits is superior to the earth auger for sampling peat.

Samples of peat should typify the entire deposit from which they are taken or a definite portion of it. Specimens consisting of material taken at depth intervals of 1 foot and at areal intervals of 100 yards in a small shallow deposit are usually adequate to represent the general composition of the deposit. It is obviously impossible to obtain a typical sample of the peat in a large deep deposit. Such a deposit should be divided into blocks and typical samples

[1] Davis, C. A., The uses of peat for fuel and other purposes: Bur. Mines Bull. 16, p. 71, 1911.

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should be obtained from each block. In large deposits samples are generally taken at depth intervals of 2 feet and areal intervals of a quarter of a mile. The material taken in each block may later be mixed in order to obtain a representative composite specimen. Structural features should be noted as deposits are sampled, and if the peat is distinctly bedded, samples should be taken from each bed and separately analyzed. If the lower strata contain a large proportion of inorganic impurities, that fact should be noted, in order that these strata may be avoided in excavation. As analyses of dry peat show its chemical composition and fertilizer and fuel values as well as analyses of wet peat, it is unnecessary to place samples taken for analyses in air-tight containers. For a simple test about 10 pounds of raw peat is required, and for a detailed chemical analysis about 40 pounds. Samples should ordinarily be air-dried to a moisture content of about 50 per cent in the field and sent to the laboratory in canvas bags. However, if it is desired to identify the plant remains, small specimens should be placed in sealed bottles or air-tight soil cans so that the peat may later be examined under the microscope in its native condition.

Black, thoroughly decomposed, friable peat from a deposit that has been well drained, aerated, and successfully cultivated for several seasons is usually suitable for an ingredient of commercial fertilizers or, when inoculated with nitrifying organisms or composted with manure, for a direct fertilizer.

Some evidence of the fuel value of peat may be obtained from a small sample that has been macerated in the hands, pressed into a cake, and allowed to dry in the sun. If it is easily disintegrated and plastic while wet, it may be readily worked in a peat machine, and if, when dry, the cake is dense, tough, and hard, the peat will probably make good fuel unless the ash content is too high. However, if the dry peat cake is soft, fibrous, and easily crushed, the peat is not well adapted to the manufacture of fuel.

The heating value and ash content of prospective peat fuel for home consumption may be determined by a simple practical test. A typical sample should be taken from the bog, thoroughly macerated, dried, and weighed. If when burned in an ordinary heating stove the heat generated is a little less than that produced by ordinary bituminous coal, and if after complete combustion the weight of the accumulated ash does not exceed 20 per cent of the weight of the dry peat put into the stove, its usefulness as domestic fuel is established.

PREPARATION OF SURFACE.

The surface of peat deposits must be prepared by draining and clearing before the peat can be removed. The water level should be reduced by a system of tile drains or ditches to a point between 2 and 3 feet below the surface. Only deposits that can be cheaply drained should be selected. Many bogs are easy to drain, but the drainage of some peat-forming basins is so difficult that their surfaces can not be economically prepared for peat production by known methods. Marsh deposits and bogs are cleared by removing the living grasses and mosses and grubbing out the

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shrubbery. The clearing of swamps overgrown by mature trees is expensive, but this expense is sometimes offset by the value of the timber obtained.

PROCESSES AND MACHINERY.

The failure of many peat plants in the United States has been due to improper choice of manufacturing processes and machinery. The excess moisture in the peat must be eliminated at as early a stage as possible in the manufacturing process. This can be most economically done by evaporation on the surface of the deposit. Whether for the manufacture of fertilizer or fuel, machinery of proved efficiency must be selected. Field equipment propelled by caterpillar drives seems well suited for use on boggy surfaces. The most successful peat-fuel machinery that has been used in North America was designed by the Canada Department of Mines and recently operated at Alfred, Ontario. Mr. John N. Hoff, of New York, N. Y., is the inventor of peat-fertilizer machinery that has been successfully used by him on a deposit near Great Meadows, N. J., for several years. Experimental work is always commendable if properly limited, but the methods and machinery that have proved successful in North America and in the peat-producing countries of Europe should be given first consideration. The peat industry of European countries is well developed, and detailed information concerning European peat machines is available in Bureau of Mines Bulletin 16 and in the report of the Canada Department of Mines cited on page 350.

MARKETS.

The principal markets for fertilizer peat are in or near some of the agricultural States, notably Maryland, New York, New Jersey, Illinois, Virginia, Kentucky, Tennessee, and Florida, and the largest buyers are the manufacturers of commercial fertilizer, brokers in fertilizing materials, florists, and farmers. Markets could probably be created in all the agricultural States. Stock-food peat is sold to manufacturers of stock feed and to growers of live stock. Many of the peat deposits in this country are located in regions remote from the coal fields, and it seems that markets for peat fuel might therefore be created in some of the peat States.

DEFINITIONS.

The terms "peat" and "muck" are often used interchangeably to designate either of those materials. This practice is confusing and should be discouraged. Peat is the partly carbonized organic residuum produced by an arrest in the decomposition of roots, trunks, and leaves of trees, twigs, shrubs, mosses, and other vegetation covered or saturated with water. It contains a large proportion of the carbon of the original vegetable matter, and in most peats the vegetal structure is visible without the microscope. Peat is usually acidic, and the quantity of inorganic matter is materially less than that of the organic, pure peats often containing less than 4 per cent of inorganic impurities. Muck is uncarbonized organic soil containing a large proportion of inorganic mineral. However, it is difficult to

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define the line of demarkation; peat may grade into muck and muck into peat. If the material will ignite and burn freely when dry it is usually considered peat.

ORIGIN.

The formation of peat is dependent on conditions favorable to the profuse growth of plants and to the escape of the plant débris from complete decomposition by bacterial and chemical action, conditions which are governed by topography and climate. If the land surface contains depressions, flat or gently sloping, poorly drained areas in which water may collect and permanently stand, and if the temperature of the air and the soil is low in summer or the humidity of the air is high enough to prevent rapid evaporation, peat-forming plants will flourish.

Glaciation was the dominant factor in the distribution and origin of most of the peat deposits in this country as well as of many in Canada and Europe. These deposits for the most part occupy lakes, marshes, and ponds formed during the last glacial epoch. Another factor in the distribution of peat is the character of the surface rock, which in many regions determines the topography. When the earth's surface, composed of rock formations that vary in hardness, is subjected to stream or glacial action, surface depressions develop. Some of the peat deposits of the New England States owe their origin to this diversity of surface rock. Basins in which peat may accumulate are also formed in a few limestone regions by solution.

Next in importance to glaciation in peat formation are wave and stream action and coastal subsidence. Many peat deposits of salt and fresh-water origin are found in drowned valleys where the coast has subsided and land-locked lagoons have been formed behind barriers erected by wave action or where deltas have been built up and the coast has subsequently risen, resulting in the formation of flat, imperfectly drained inland areas. In some places salt-marsh peat underlies peat of fresh-water origin and in others the reverse, indicating the fall and rise of the seacoast.

Abundant and evenly distributed rainfall, high humidity, and a cool or moderate temperature are the most favorable climatic conditions for fresh-water peat formation. All these conditions are present in the northern peat region and in varying degrees in the coastal region. Peat sometimes forms in the Frigid Zones, but not extensively, and also in the Torrid Zone, although owing to the high temperature, plant débris decays there rapidly, and despite profuse plant growth peat accumulates slowly and therefore contains a high percentage of inorganic matter. For good tropical peat a heavy rainfall well spread through the year is essential.

On account of the good drainage no peat of consequence is found in the Appalachian and Rocky Mountain regions, nor, because of scanty rainfall, in the area between the Rocky Mountains and Mississippi River, except in Minnesota and Iowa. Contrary to the general belief, there is little peat in commercial quantities in the lower Mississippi Valley, a condition due partly perhaps to high temperature, but mainly to the vast amount of alluvium carried and deposited from time to time by Mississippi River and its tributaries.

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Although hundreds of different plants have been identified in the bogs and swamps of this country, comparatively few contribute the mass of the vegetable débris from which peat forms. The most common are trees, heath shrubs, sedges, grasses, mosses, pondweeds, water lilies, reeds, cattails, and ferns. When given a favorable environment most of these plants multiply rapidly and soon predominate over their competitors; in fact, in some areas they grow so densely that man penetrates them with difficulty, and an immense quantity of dead vegetation accumulates annually.

One of the chief substances formed by plants during growth is cellulose, which consists of carbon, hydrogen, and oxygen. These constituents are absorbed by the leaves from atmospheric gases and by the plant roots from the soil. Cellulose, because of its complex composition, is an unstable compound and when attacked by fungi and bacteria rapidly decomposes. If at the end of the growing season the plant débris falls upon drained soil, it is vigorously attacked by these microorganisms, and the carbon and hydrogen of the cellulose unite with the atmospheric oxygen and with each other, forming carbon dioxide and water. In other words, if oxidation is unhampered, the organic matter will disappear in a relatively short time. If, however, the plant matter falls in large quantities into water or upon soil saturated with moisture, it undergoes a different change from the decay suffered by exposed vegetation. The atmospheric oxygen is largely excluded and as the activity of fungi and bacteria, which usually cause complete decay, is controlled by the supply of air, upon which they depend for their existence, decay is slow, and a large proportion of the fixed carbon is retained. The salient features in the evolution of peat from cellulose are the elimination of hydrogen and oxygen as water and of carbon and oxygen as carbon dioxide and the generation of methane. This is the process of carbonization.

If surface conditions are unchanged the process of carbonization is largely arrested with the formation of peat, and the accumulation of organic matter may exist indefinitely as peat unless the land is drained and decomposition again begins. If, on the other hand, the peat is deeply buried beneath superposed deposits, generally muds, sands, and limestone, and is subjected to pressure, with varying degrees of heat, lignite, bituminous coal, anthracite, and graphite are succeeding stages in the process of carbonization. It seems, therefore, that most coals of the common types were once peats, that most coal fields were formerly swamps, and that the formation of peat in the bogs and swamps of this country is an existing example of the first stage in the process of coal formation. It has been shown that deposits essentially similar were laid down in many parts of the United States during the Carboniferous period.

DISTRIBUTION AND QUANTITY.

The most extensive peat deposits in the United States are found in a region which lies east of the ninety-seventh meridian and north of an irregular line drawn eastward through the northern sections of Iowa, Illinois, Indiana, Ohio, Pennsylvania, and New Jersey, and approximately includes the area covered by the Wisconsin or last

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glacial drift. (See Pl. III.) Many workable peat beds occur also in areas extending 25 to 50 miles inland on the Atlantic coast from New Jersey to southern Florida and along the gulf coast to the Mexican boundary, and there are a few workable beds of peat in the Pacific Coast States.

The areas of peat accumulation in this country may, therefore, be roughly assigned to two major regions, the northern or glacial and the coastal, and this subdivision, though partly geographic, expresses the chief differences in manner of formation and in the quality of the peat. The northern peat region includes Minnesota, Wisconsin, Michigan, New York, northern New Jersey, the New England States, and the northern sections of Iowa, Illinois, Indiana, Ohio, and Pennsylvania. This region is characterized by the presence of numerous small lakes and marshes formed as a result of glacial action during Pleistocene time, and by relatively low temperature and high humidity, and most of the peat originated in basins. Moss, sedge, grass, and tree peat are abundant, and much sphagum is found growing on bogs in Maine and in the northern counties of Minnesota, Wisconsin, and Michigan. The deepest and most extensive deposits in the New England States lie east of the Berkshire Hills and the Green Mountains.

The Atlantic coastal region embraces southeastern New Jersey, the eastern parts of Delaware, Maryland, Virginia, North Carolina, South Carolina, and Georgia, all of Florida, the southern parts of Alabama, Mississippi, and Louisiana, and coastal Texas. The nearness of the ocean causes heavy rainfall and high relative humidity in this region, and the deposits are found in drowned valleys and lagoons formed by the gradual subsidence of the Coastal Plain and by wave action and on flat, imperfectly drained areas farther inland. The region is typified by many fresh and salt water marshes and by swamps in which the deposits have been formed largely by trees, marsh grasses, and other plants, some of which tolerate salt water around their roots. On the Gulf coast, owing to the hot climate, dead vegetation decays rapidly, and as the peat therefore accumulates slowly it contains much ash. The most extensive peat deposits in the coastal region occur in Florida.

Although there are a few peat deposits on the New England coast that are related in origin and composition to those classed in the coastal region, by far the most numerous bogs of the northeastern States are of the glacial-lake kind, and the region as a whole should be so considered in a classification of the major peat regions.

The known workable peat beds of the Pacific coast region occur in Orange, Los Angeles, and San Bernardino counties, Calif., and in the basins of several of the lakes and rivers of Washington and Oregon, but peat deposits of commercial extent are comparatively rare in this region.

The total quantity of good peat in the United States, exclusive of Alaska, was estimated in 1909 to be about 12,889,000,000 short tons,[1] but recent field investigations by E. K. Soper and others seem to justify an increase of this figure to 13,826,000,000 tons.

[1] Davis, C. A., Peat resources of the United States exclusive of Alaska: U. S. Geol. Survey Bull. 394, pp. 65–66, 1909.

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Approximate distribution and quantity of air-dried peat in the United States.

	Short tons.
Northern region	11,053,000,000
Atlantic coastal region	2,701,000,000
Other regions	72,000,000
	13,826,000,000

USES.

WAR-TIME USES AND POSSIBILITIES.

A review of conditions in the peat industry during the year in which the great world war terminated seems a fitting place to record the war-time uses and possibilities of peat and its relation to the welfare of a warring nation. Peat and peat moss are used in the manufacturer of fertilizer, fuel, and surgical dressings, products which, though necessary in time of peace, are vital in time of war.

Peat was extensively utilized in nearly every European country during the war to supplement inadequate supplies of coal and fertilizer, and many governmental plants were erected for its production. In some countries prices were fixed to prevent extortion and measures were adopted by the Governments to stimulate production. As imports of coal into some countries were greatly curtailed, much suffering and financial loss resulted, despite the large output of peat from domestic sources, but because of this increased production of peat fuel, which was extensively used by domestic consumers and in hospitals, great hardship was avoided by some people and many lives were saved.

The collection of sphagnum, or peat moss, was another important war activity that assumed large proportions in Europe. The gathering of surgical moss by volunteer labor was considered a patriotic duty in England and Scotland, and before the armistice was signed the question "Are you gathering moss?" assumed the nature of a byword. Millions of moss pads were used during the war, and the supply of cotton available for the manufacture of munitions was thus greatly augmented.

In the United States, on account of our immense coal reserve and large output of cotton, peat did not take a large part in war activities, but by furnishing nitrogen to the fertilizer industry it released nitrates for the manufacture of explosives, and was thus of some assistance in the prosecution of the war. More than half a million peat-moss pads were prepared in this country and sent to domestic and foreign military hospitals. It is understood that a plant for the manufacture of nitrate from peat was in process of erection when the armistice was signed. Shortly after this country entered the war the United States Geological Survey directed attention to the vast peat deposits of this country located in regions remote from the coal fields and suggested the production of hand-cut peat fuel for local use by the owners of small deposits. It appears from reports that many people responded and that more peat fuel was produced in the United States in 1918 than in all preceding years. Our peat deposits are of great potential value as a source of fuel, fertilizer, nitrate, and antiseptic material.

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PEAT IN AGRICULTURE.

FERTILIZER.

The peat deposits of the United States are one of the few extensive known domestic sources of nitrogen that can be converted into plant food at a price that is economical to the farmer. The average nitrogen content of domestic raw peat is about 2 per cent, although many peats contain more than this quantity. This nitrogen may be recovered in the form of ammonium sulphate or may be made available for plant food without extracting it from the peat. Arguments are often advanced against the direct use of peat as a source of nitrogen in soil fertilization because all of this element shown by chemical analysis is not readily available for plant food, but this criticism seems to be based on a misconception of the nature of peat. It is true that only a part of the nitrogen shown by analysis can be immediately used for food by plants, but it is equally true that a chemical analysis of peat is not a fair test of its value as a fertilizer and that the total quantity of potential soluble nitrogen formed and released by bacterial action from time to time after the peat has been applied to the soil is in the aggregate much greater than the percentage found in some commercial fertilizers.

Fortunately all of the nitrogen in peat is not soluble at one time, or it would leach out and the potentially rich black peat soils of this country would be unproductive.

The largest use of peat in the United States for the cultivation of crops, exclusive of the direct cultivation of peat soils, is in the form of a nitrogenous ingredient of commercial fertilizers. In fact some of the large manufacturers of commercial fertilizer rely on peat to contribute a substantial proportion of the nitrogen content of their product. It is said that good peat when properly prepared for this purpose will contribute nearly 5 per cent of its total weight as nitrogen.

A new process for the commercial application of bacteriology to soil fertilization was reported in 1918 by John N. Hoff, of New York, N. Y. According to his method the peat is cultivated for several seasons, excavated, air-dried, neutralized or made slightly alkaline, and is used as a carrier and energizer of several varieties of legume and other bacteria.

PEAT SOILS.

Peat soil when properly treated is one of the most fertile types of soil in this country. Owing to the abundance in previous years of well-drained land that could be more readily tilled, the peat and muck areas have been passed by; but with the rapid increase of our population and the advent of intensive soil cultivation the attention of agriculturists and others is now being directed to these neglected lands. In the eastern section of this country there is approximately 15,000,000 acres of peat and muck land supporting a growth of shrubs, tamarack, white cedar, birch, water maple, gum, and cypress, and only about 750,000 acres, or 5 per cent of the total area, has been reclaimed for agriculture. Secretary Franklin K. Lane, in advocating the reclamation of the swamp and cut-over timber lands of the

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United States and their sale on deferred payments to discharged soldiers, sailors, and marines, said in substance in a recent statement for the press:

> There are approximately 200,000,000 acres of cut-over or logged-off timber land in the eastern half of the United States and, overlapping to a certain extent the cut-over lands, some 80,000,000 acres of swamp land located largely in the southeastern section of the country.
>
> To the ordinary observer the reclamation of these waste areas may seem difficult. The soil, however, is in many instances very fertile. For many years leaf mold containing humus has been accumulating, and once the stumps have been blown out and the land cleared of brush and brought under the plow, it is believed that these lands will prove among the most fertile of our agricultural resources. Like the Dismal Swamp in Virginia, or the Everglades in Florida, most of the swamp land in its present condition is unfit for human habitation. Consider this land cleared of its timber, adequately drained, and intensively cultivated, and some idea of its possibilities for the production of food will be obtained.

Raw peat soils, though too acidic for ordinary farming, are after they have been drained, cleared, freely aerated, and properly fertilized, especially well adapted to the production of vetch, redtop, millet, buckwheat, oats, corn, rye, the potato, the cranberry, the blueberry, the strawberry, and other acid-tolerant crops.[1] If properly treated with potash salts and with lime they are neutralized or made slightly alkaline and should then yield large quantities of red clover, timothy, blue grass, wheat, rutabagas, and other alkaline or neutral-soil crops. The greatest returns derived from the cultivation of peat, however, have arisen from its use as a truck crop soil. According to the Bureau of Soils,[2] cabbage, onions, celery, lettuce, spinach, carrots, beets, turnips, and peppermint are the most valuable crops that are grown on treated areas of peat. The acreage values of these crops so far surpass those of the general farm crops that the reclamation of any large areas of peat should be undertaken with the special object of their production.

The fertility of peat soil is chiefly due to its nitrogen and humus contents, to its affinity for moisture, and to its black color, which enables it to absorb heat. For the profitable production and sale of both general and special crops, it is desirable that such areas of peat as are close to large city markets and accessible to good transportation and cheap labor should be first reclaimed.

The first attempts to use peat lands for the growth of crops were made in the older agricultural districts of the Eastern States, notably New York and New Jersey. Some of the most productive farm lands in those States were formerly peat bogs and swamps. The truck farm of John N. Hoff near Great Meadows, Warren County, N. J., the well-known onion farms of the Wallkill River valley, Orange County, N. Y., and the Oak Orchard lands north of Batavia, N. Y., are reclaimed peat deposits. Thousands of acres of land in these States now under intensive cultivation are underlain by peat from 10 to 15 feet deep. Nearly half a million acres of peat land in the Dismal Swamp district of Virginia and North Carolina is successfully devoted to the growth of potatoes, corn, wheat, and other crops. An average of more than 30 bushels of wheat to the acre has been obtained for several years on the well-tilled farm of

[1] Coville, F. V. The agricultural utilization of acid lands by means of acid-tolerant crops: U. S. Dept. Agr. Bull. 6, 1913.
[2] U. S. Dept. Agr. Bur. Soils Cir. 65, pp. 13–14, 1912.

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the Wallace Bros., in the Dismal Swamp, Va. Peat soils are also extensively used for crop cultivation in Minnesota, Wisconsin, Michigan, Iowa, Illinois, Indiana, and Ohio. Thousands of acres are already under cultivation, and millions may be reclaimed by proper drainage and clearing. In fact, the economic future of entire counties seems to be directly dependent upon the successful reclamation of peat bogs and swamps.

Many peat soils require careful fertilization before crops can be successfully grown upon them. This is especially true of deep peat, as the plants are unable to obtain certain necessary minerals from the subsoil. Potash is required by many peats, and phosphates and nitrates by some. However, if subjected to intensive plowing and thoroughly aerated, well-decomposed peats are usually rich in nitrogen. If it is desired to raise alkaline-soil crops and the acidity of the peat can not be corrected by plowing and aeration, lime should be applied.

Many peat areas in the northern or glacial region are underlain by beds of marl, a white or gray claylike variety of limestone composed largely of calcium carbonate ($CaCO_3$) brought into lakes and marshes by springs or stream waters and precipitated through the agency of blue-green algae and stoneworts (*Chara*). The plants extract carbon dioxide from the water and thus cause the deposition of the lime held in solution. Deposits of fresh-water marl are common in the southern peninsula of Michigan, in northern Indiana, in western New York, and in northwestern Pennsylvania. Shell limestone deposited by organisms is another common kind of calcareous material frequently found beneath peat in the coastal region. Dense, fine-grained limestone, marble, travertine, oolitic limestone, and chalk, though not commonly associated stratigraphically with peat, occur in many regions near peat deposits. There are, therefore, many peat areas in this country which on account of their acidity are of little value for general farming but which could be economically treated with lime from associated or adjacent deposits and made to yield large alkaline or neutral-soil crops.

Where it has been properly used the application of lime to peat soil has resulted in increased fertility. The limestone should be ground or burned before use as fertilizer, as the lime is then available immediately, whereas if applied in an untreated condition some varieties of limestone, notably shell "marl," are relatively inactive the first year. The chemical and physical effects of liming are manifold. It releases potash from certain silicates; it promotes the decomposition of the peat, freeing soluble nitrogen; applied to sour soils, it corrects the acidity; and applied to peat soils that harden in lump form upon drying, it renders them easily workable.

PEAT FUEL.

MACHINE PEAT.

The following data[1] based upon the experiments of the Canada department of mines show the cost of a machine peat-fuel plant and of producing air-dried machine peat in commercial quantity in

[1] Haanel, B. F., Peat, lignite, and coal: Canada Dept. Mines, Mines Branch, Pub. 299, p. 27, 1918.

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Canada before the war. The cost of production was calculated from an output in five months of 3,300 short tons of fuel containing 25 per cent moisture.

Cost of 30-ton Anrep peat plant.

100 acres of peat land, at $6 an acre	$600.00
Peat machine, locomobile, tracks, cars, cables, etc	7,500.00
Blacksmith shop, office, loading platform, and railway siding	1,100.00
Drainage, clearing, etc	1,500.00
	10,700.00

Cost of producing a ton of air-dried machine peat.

Labor and supervision	$1.21
Repairs, fuel, oil, waste, etc	.15
Amortization and interest	.34
	1.70

PEAT BRIQUETS.

Peat briquets are usually made from raw peat that has been air dried to a moisture content of 40 per cent. After the peat has been macerated and powdered, the moisture is further reduced to about 15 per cent by artificial drying. A binder is then mixed with the peat and the mixture is compressed into cylindrical or prismatic shape by means of a piston subjected to a pressure of 18,000 to 30,000 pounds to the square inch.

Although there is a little more heating value per pound in peat briquets than in machine peat, the briquets are cleaner, more compact, greater in heating value per volume, and generally more attractive than machine peat. These advantages, however, are more than offset by the high cost of production. Artificial drying requires nearly as much heat as that obtainable from peat briquets prepared in this manner, and the cost of binders and compressing is so great that the process is of doubtful commercial value in the United States.

PEAT COKE AND CHARCOAL.

Peat charcoal was made in Europe for hundreds of years by piling cut peat in dome-shaped heaps, covering it with soil, and burning the peat with a restricted supply of oxygen. This process is little used now and peat charcoal has been displaced by peat coke, which is manufactured in Europe by the Ziegler process.[1] According to this method the coke is produced by heating machine peat blocks in specially designed retorts. Good peat coke is equal in quality to the best grades of charcoal produced from wood. If made from blocks of well-macerated, thoroughly decomposed peat that contains little ash, peat coke is compact and hard and should be able to compete with coke manufactured from coal. Alcohol, acetic acid, ammonia, ammonium sulphate, paraffin wax, illuminating and lubricating oil, phenol, and asphalt are some of the valuable by-products that may be obtained in coking peat by the dry distillation process.

Peat coke is extensively used in Europe, but in the United States, though it could probably be prepared for about $4 a ton, this material

[1] Nystrom, E., Peat and lignite, p. 176, Canada Dept. Mines, Mines Branch, 1908.

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has never been commercially produced. There are large deposits of peat suitable for the production of coke within a few miles of the iron-mining districts of Minnesota, and it seems that the practicability of locating peat-coke plants in this regon should receve thoughtful consideration from engineers.

There are two kinds of by-product gas-producing plants that use peat—the Mond and the Frank-Caro.[1] The same principle is applied in both and the diffierences between them are minor. Crushed peat is fed into a furnace in which combustion is regulated by steam and hot air. The peat burns at the bottom of the feed shaft, and, reacting upon the steam, forms water gas and ammonia. These gases are next cleansed of tar by means of a scrubber and are subjected to a fine shower of sulphuric acid, which converts the ammonia into ammonium sulphate and purifies the water gas. After being cooled the water gas may be used under steam boilers, in internal-combustion engines, and for other purposes.

It is said that at Cordigoro, Italy, peat containing 2.5 per cent of combined nitrogen, when treated by the Mond process, yielded 170 pounds of ammonium sulphate to the ton. Gas-producing plants using peat fuel have been operated in England, Ireland, Germany, Sweden, Italy, and Russia, but not in the United States, although experiments have been made here. Analyses of the peats of the United States show that they are rich in combined nitrogen, from 70 to 85 per cent of which—a proportion that in some peats amounts to more than 2 per cent of their dry weight—could be recovered in the form of ammonium sulphate in by-product gas-producing plants.

OTHER USES.

PACKING MATERIAL.

Because of its lightness, resiliency, and antiseptic properties, peat makes excellent packing material and has long been used for packing eggs, fruit, vegetables, and fragile articles. Dry peat is a nonconductor of heat and hence is valuable in ice houses and as packing for water pipes. The best material is obtained from the fibrous types of peat consisting of partly disintegrated grasses and mosses. Peat moss is also utilized by florists and nurserymen in shipping flowers, shrubs, and plants.

PAPER, WOOD, AND CLOTH.

Peat was used a few years ago at a plant near Capac, Mich., for the manufacture of cardboard and paper. Grass and sedge peat would probably make the best paper stock, as this peat consists of strong fibrous material. It is understood that rugs are also made in this country from incipient sedge and grass peat. Peat has been successfully used in Europe for the manufacture of wall board and other artificial wood products. German and Swedish manufacturers have also made a durable yarn from a mixture of peat moss, shoddy, and wool, from which a cloth resembling cheviot is woven.

[1] U. S. Geol. Survey Bulls. 290 and 332 and Prof. Paper 48; Bur. Mines Bulls. 4, 7, 9, 13, and 16. Wyer, S. S., Producer-gas and gas producers, 1907. Haanel, B. F., Peat, lignite, and coal: Canada Dept. Mines, Mines Branch, Pub. 299.

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MUD BATHS.

At certain health resorts in Germany and Austria peat has long been successfully used for so-called "mud baths," and during recent years experiments have been made to test the healing properties of peat in some of the sanitariums of this country. Well decomposed peat, free from coarse or woody material is the basis of the mixtures used, and it is reported that persons suffering from rheumatism and like diseases are materially benefited by the treatment.

PEAT INDUSTRY IN PRINCIPAL FOREIGN COUNTRIES.

GENERAL CONDITIONS.

The year 1918, as a result of the rather general shortage and high prices of coal, was one of great expansion and prosperity in the peat industry of most European countries. The quantity of peat produced and sold in some of these countries exceeded the quantity marketed in any preceding year. More peat fuel was produced than any other peat product, but the most interesting development was the world-wide use made of peat or sphagnum moss in the preparation of surgical dressings.

RUSSIA.[1]

Stimulated by war and the consequent shortage and high price of coal, the output of peat fuel in Russia in 1918, was approximately 10,000,000 metric tons, or almost double the quantity produced in years preceding the war. Of this quantity about 7,000,000 metric tons was manufactured in the central provinces. The sale of peat fuel machines, which affords a fairly reliable index to the ratio of increase in production, has more than doubled in recent years.

The Electrical Transmission Co., of Moscow, which annually supplies that city with approximately 40,000,000 kilowatt hours of electrical energy by the use of peat, recently applied to the Russian Government for a loan of 8,000,000 rubles to meet the high cost of labor occasioned by the war. It is understood that the minister of trade and industry recommended that the request be granted.

GERMANY.

Information concerning conditions in the peat industry of Germany has been difficult to obtain during the war, but the following data furnished by Sergt. H. E. Stanley, of the American army of occupation, and made available to the survey through the courtesy of the Fertile Chemical Co., of Cleveland, Ohio, indicate that the production of peat fuel in Germany has reached a high state of development:

Extensive peat beds, varying in depth from 1 to 17 meters, are found between Bruhl, Germany, and the Holland border. There are many plants near Bruhl and Liblau, where deep peat of good quality is found. About 35 peat-fuel plants are also located between Bruhl and Cologne and more than this number north of Cologne.

After the peat has been excavated, it is loaded in buckets, which are carried on aerial cables from the deposit to the plant, in some instances a distance of 2 kilometers. The raw material is run through a macerator, pressed into blocks,

[1] Am. Peat Soc. Jour., vol. 11, 2, pp. 50–53, 1918.

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and stamped with the firm name. It is said that when the peat reaches the plant it contains about 80 per cent of moisture, which is reduced to 15 per cent by natural and artificial drying. As most of the work is done by machinery, little hand labor is required.

DENMARK.

Conditions in Denmark in recent years have been decidedly favorable to the expansion of the peat industry. The following table, based upon data furnished by John Olsen, of Arlington, Mass., shows the stimulating effect of the coal shortage during the war on the peat-fuel industry of Denmark:

Air-dried machine peat produced and consumed in Denmark, 1914–1918.

Year.	Number of producers.	Quantity (metric tons).	Average price per ton.	Value.
1914	65	86,849	(a)	(a)
1915	69	95,145	$4.08	$388,191
1916	160	118,484	6.43	761,852
1917	564	397,846	7.70	3,063,414
1918	1,380	851,546	7.00	b 5,960,822

a Not available. b Estimated.

There are two processes of producing machine peat in Denmark, the wet and the dry. According to the wet process, which is the one in most general use, water is added to the peat as it is put through the machine, and the resultant mudlike mixture is then spread out on drying fields and molded or cut into bricks by hand. This process, which originated in Denmark, produces a firm, dense brick particularly well adapted for industrial fuel. In the dry process the peat is macerated without the addition of water and cut by the machine into bricks, which are then spread out on the drying field.

Producers of hand-cut peat reported an output of 1,407,435 metric tons, estimated to be worth $9,039,178. A basic price of $7 a metric ton for peat having a combined ash and moisture content of 40 per cent was established in 1918. About 60 per cent of the machine peat produced in Denmark in 1918 was used for industrial purposes, and the cut peat was largely consumed in households. A series of tests was made with peat as locomotive fuel, and peat was used regularly on two branch lines with good results. The distances run during tests were from 45 to 85 miles, and the peat consumed amounted to 6.7 pounds per car-mile.

A textile industry in Denmark, based upon peat, seems to be a prospective result of experiments recently conducted in that country.[1] It is reported that a grayish material resembling woolen cloth is woven from yarn 75 per cent of which consists of peat fiber and 25 per cent of woolen waste. Knitting machines by which hosiery was made from peat yarn were shown in 1918 at an exhibition in Goteborg. A plant for the manufacture of peat yarn has been established at Silkeborg, and other factories will probably be erected. A new corporation, known as the Dansk Mose-Industri, with a capital stock of $34,840, was organized at Aarhus, Denmark, in 1918, for the production of peat products. A peat-briquet factory is also being erected at Brondersler.

[1] Commerce Repts., Oct. 9, 1918.

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SWEDEN.

The output of machine-peat fuel in Sweden in 1917 was approximately 100,000 metric tons, compared with only 22,500 tons in 1916. These figures do not include hand-cut peat produced by peasants for local use, which probably amounts to more than the output of machine peat.

A large quantity of powdered peat was used in Sweden in 1918 for the generation of steam in locomotive boilers. A description of the type of locomotive adapted to use powdered peat for fuel and of the method of operation is given in a recent report to the Department of State by the United States Ambassador at Stockholm, Sweden.

Material progress was made in Sweden in 1918 toward the development of a peat cloth industry.[1] It is said that an economical method has been devised for extracting, carding, and spinning peat fiber. Plants were constructed at Hadenge, in Jonkoping Len, and at Goteborg for the manufacture of peat cloth from which matting, felt, carpet stuff, and even clothing may be made. The plants are reported to be capable of producing peat yarn at 4 cents a pound which can hardly be distinguished from wool.

It is reported[2] that mineral oil may be extracted from the peat deposits of Sweden and that there are good opportunities in that country of thus building up a domestic oil industry. Good air-dried Swedish peat yields, by dry distillation, from 5 to 8 per cent of tar, from which motor, illuminating, and lubricating oils, paraffin, and creosote may be extracted.

Many new companies for the production of peat were organized in Sweden in 1918, the largest of which is the South Swedish Peat Industry Union, capitalized at $1,000,000, and capable of producing 12,000 metric tons of peat annually. It is estimated that Sweden contains about 12,355,220 acres of peat.

BRITISH ISLES.

Peat in the form of crude hand-cut blocks has been the only fuel of many Irish peasants for centuries. It is estimated that Ireland contains 3,000,000 acres of peat land, a quantity sufficient to meet the needs of that country for a thousand years. Despite this vast reserve, peat fuel was scarce in Ireland in 1918, and the price rose in some parts of the country from $1.20 to $4 a horse load, or about $10 a short ton. There has been much discussion recently in Great Britain concerning the use of Irish peat as a source of fuel for the generation of electricity, and an experiment to demonstrate the potentialities of peat for this purpose was begun in 1918. It is believed that this is the most efficient use of peat that can be made, and that if peat fuel of better quality than that produced by the peasants for use in their own homes could be supplied at a low price the domestic welfare of the Irish people would be materially improved.

The following excerpt from a report[3] relating to the peat resources of the British Isles indicates that peat attracted wide attention in 1918:

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[1] U. S. Commerce Repts., 163, p. 169, 1918.
[2] Berlingske Tidende, Copenhagen, Denmark, 1918.
[3] Sherman, H. T., Suggestions for coal substitutes: Consular Rept., Nov. 25, 1918.

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The scarcity of coal in Great Britain caused by the lack of miners raised the question in 1918 of coal substitutes, and peat was mentioned as a prospective low-grade fuel.

The peat deposits of England, Scotland, and Wales have been almost untouched because of the abundance and low price of coal, but war conditions, necessitating the conservation of coal supplies, have directed attention to the larger utilization of peat for the generation of heat and power. According to the estimates of engineers who have studied the subject there are immense reserves of peat in the British Isles. The peat deposits of the United Kingdom are estimated to cover more than 6,000,000 acres and to contain material equivalent in heating value to 5,000,000,000 metric tons of anthracite coal.

Although peat fuel was not extensively used in England and Scotland in 1918, nearly 12,000,000 peat-moss pads were prepared and used in British military and naval hospitals in that year. Figures concerning the value of these pads are not available, but it is estimated that if absorbent cotton had been used exclusively in the hospitals the increased cost of antiseptic pads would have been about $200,000.

SWITZERLAND.

The shortage of coal in Switzerland in 1918 led to the use of peat as a source of gas. The Demolis process, by which the excessive carbon dioxide is converted into carbon monoxide in passing over wood charcoal, is used.

CANADA.

Conditions in the peat-fuel industry of Canada are like those in the United States. Although Canada has many large peat deposits, coal is the staple fuel, and little has been done to produce peat fuel commercially. The following excerpt[1] shows the efforts that have been made by the Canadian Government to stimulate the production of peat fuel:

Efforts have been made for many years to develop the peat deposits of Ontario and Quebec. Large sums of money have been spent by individuals and companies and yet there is little peat fuel produced commercially in Canada. About six years ago, however, the Government decided to make a practical investigation of peat production, and if possible to demonstrate the value of peat fuel. Representatives were sent to Russia, Germany, Holland, Denmark, and Sweden to collect data relating to peat-fuel production. When these agents returned 300 acres of peat land near Alfred, Ontario, was purchased and peat fuel was manufactured by the process which had been most economical in Europe. Approximately 2,000 short tons of peat was produced at a low cost and sold to householders and manufacturers, and it was reported by them that the peat proved to be satisfactory fuel. After this successful demonstration the Government believed that its work had been accomplished and that further development should be left to private interests. Accordingly the plant was sold, but the buyers were undercapitalized and further handicapped by the outbreak of the war, and consequently the plant ceased to operate.

In the spring of 1918, owing to the fuel shortage occasioned by the war, attention was again directed to the peat deposits and money was appropriated by the Federal Government and the provincial government of Ontario for a further demonstration of peat-fuel production. A peat committee was named, and Ernest V. Moore, of Montreal, was selected as engineer to conduct the experiments. The erection of two plants was begun, one of which was modeled after the Alfred plant mentioned and the other was a new design calculated to meet the slight defects of the former. It is understood that both machines will excavate, macerate, and spread out the peat for air drying as they move over the

[1] Armstrong, J. E., The peat bogs of Canada: Am. Peat Soc. Jour., vol. 11, No. 2, p. 52, 1918.

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surface of the bog. At the close of 1918 the plants were not completed, but it is said that they will be operating at their full capacity of 6 tons each per hour during the summer of 1919.

Peat fuel produced in Canada, 1900–1916.

Year.	Quantity (short tons).	Value.	Year.	Quantity (short tons).	Value.
1900	400	$1,200	1909	60	$240
1901	220	600	1910	841	2,604
1902	475	1,663	1911	1,463	3,817
1903	1,100	3,300	1912	700	2,900
1904	800	2,400	1913	2,600	10,100
1905	80	260	1914	685	2,470
1906	474	1,422	1915	300	1,050
1907	50	200	1916	300	1,500
1908	60	180			

URUGUAY.

It is reported[1] that rights to develop peat deposits near Maldonado, Uruguay, were acquired in November, 1917, by the Sociedad Anónima Turberas Carboníferas de Maldonado, and that since then dried peat at the rate of 20,000 metric tons a month has been produced at times, although this rate of production has not been continuously maintained for more than a few days.

PRODUCERS OF PEAT IN THE UNITED STATES.

The following individuals and companies reported to the Geological Survey that they produced crude peat or peat products in the United States in 1918:

Alphano Humus Co., Whitehall Building, New York, N. Y.
American Peat Products Co., Morrison, Ill.
Atlantic Humus Co., Newbern, N. C.
Chapman, I. S., & Co. (Inc.), 937 Third Street, San Bernardino, Calif.
Cole, Norvin G., Hopewell Junction, N. Y.
Commercial Humus Co., 503 Firemen's Building, Newark, N. J.
Day, James H., 35 South Street, Milford, N. H.
Espy Humus Fertilizer Co., Espy, Pa.
Fallows, F. H., Auburn, Maine.
Hall, George W., North Adams, Mass.
Humus Natural Manure Co., 1964 Broadway, Brooklyn, N. Y.
Hyper-Humus Co., Newton, N. J.
McElhone, Asa, Fishkill, N. Y.
New Era Development Co., 110 State Street, Boston, Mass.
Orchid Humus Fertilizer Co., 743 Frost Avenue, Peekskill, N. Y.
Pierson, A. N. (Inc.), Cromwell, Conn.
Riverside Orange Co. (Ltd.), Arlington Heights, Riverside, Calif.
St. Joseph Humus Co., Van Wert, Ohio.
Sims, Alfred F., Sag Harbor, N. Y.
Southern Humus Co., Smyrna, Ga.
Tifton Guano Co., Tifton, Ga.
Upton, Roger, Marblehead, Mass.
Virginia-Carolina Chemical Co., Richmond, Va.
Wiedmer Chemical Co., Pierce Building, St. Louis, Mo.

[1] Dawson, W. M., Commerce Repts. 47a, p. 9, 1918.

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SULPHUR AND PYRITES.[1]

By PHILIP S. SMITH.

WAR MEASURES.

The entrance of the United States into the World War necessitated a careful inventory of the country's mineral resources and the formulation of definite policies as to their proper war use. It soon became apparent that sulphur or minerals from which sulphur could be obtained were vitally necessary in the war program of the Nation for the manufacture of munitions and for the fertilizers that would augment the production of crops requisite to furnish the food and clothing that were indispensable to the successful prosecution of the war.

The principal materials used as sources of sulphur are native sulphur and pyrites. Crude native sulphur—sulphur as it comes from the ground—may contain impurities in large quantities. In the United States, however, more than 99 per cent of the native sulphur produced is mined by melting it with hot water in the rocks in which it occurs below the surface and forcing the hot liquid sulphur to the surface. Most of the sulphur produced by this method of mining is very nearly pure. In current commercial practice this sulphur is guaranteed to be 99.5 per cent pure, so that the domestic crude sulphur really contains almost no visible impurities.

Pyrites is a general trade name for a number of different sulphur-bearing minerals or sulphides. The two most common minerals are pyrite and marcasite, disulphides of iron (FeS_2), which when pure contain about 53 per cent of sulphur and 47 per cent of iron. These two minerals differ from each other principally in their mode of crystallization; pyrite usually forms cubes, whereas marcasite forms tabular crystals. Pyrrhotite (Fe_7S_8), is also called pyrites. Pure pyrrhotite contains about 40 per cent of sulphur and 60 per cent of iron.

The sulphur-bearing minerals named differ in the proportion of sulphur they yield and in the manner in which they are treated. For instance, pure native sulphur burns in the flame of a match and is entirely consumed; pyrite or marcasite may be ignited by a match but is soon extinguished, and even when all the sulphur is consumed it leaves behind a mass of iron oxide nearly as large as the original piece of pyrite; pyrrhotite will not easily ignite, yields much less sulphur, and leaves a still larger residue than either pyrite or marcasite.

[1] The statistics in this report were compiled by Mrs. Agnes L. Sullivan, of the United States Geological Survey.

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In addition to these minerals that are primarily used for their sulphur content many ores of the metals, such as those of copper, lead, and zinc, contain enough sulphur to make the utilization of their sulphur as a by-product commercially profitable. Although all these materials will yield sulphur-bearing gases the question whether they shall be used is determined largely by cost and dependability of supply. As native sulphur contains twice as much sulphur as pyrites or any other sulphur-bearing ore, if the charges for transportation are the same for all kinds, the actual charge against the sulphur in a ton of native sulphur is but half that borne by the sulphur in a ton of pyrites. Furthermore, only half a ton of sulphur need be burned to give the same volume of gas as a ton of pyrites so that less labor is required to feed it to the burners, not nearly as much residue is produced, and less labor also is required for cleaning the burners for a new charge. On the other hand, the great producing sulphur mines, near the northeast coast of Texas and the southwest coast of Louisiana, are more distant from sulphur-consuming centers of the country than are some of the deposits of pyrites.

The records of the Survey regarding sulphur materials, which have been maintained for nearly 40 years, show that in the years immediately preceding the war about 300,000 long tons of crude sulphur, 1,500,000 long tons of pyrites, and more than 1,000,000 short tons of sulphur-bearing ores of copper and zinc were produced or used for their sulphur content in the United States each year. The quantity of crude sulphur produced was so large that in 1913 about 90,000 tons were exported and about 15,000 tons were imported. This country was therefore self-sufficient, so far as its usual demands for native sulphur were concerned. The outlook for an adequate production of domestic pyrites was not so favorable. Although enormous deposits of pyrites occur in the United States, many of them are not near the places where the material is used, could not quickly be made to yield large quantities, and could not be worked in competition with deposits mined with cheap labor. As a consequence the domestic production of pyrites before the war was about 350,000 tons a year and the importation of pyrites, mainly from Spain, was nearly 1,000,000 tons a year.

The foregoing facts make it evident that many diverse interests were involved in the proper solution of the problems that arose concerning the use of sulphur materials in the many different activities of war and industry. The fundamental requirements, however, were the determination of the sulphur and pyrites resources of the country and the collection of accurate statistics of the quantity produced. These requirements had long been met by the work of the Geological Survey, which merely continued the work, but pursued it more intensively and expeditiously. Thus, instead of compiling statistics of production annually it obtained returns from all producers each month, and the figures were made available to all the war organizations of the Government through the courtesy of the producers, who released their confidential records for all Government uses. Field examinations to determine available reserves and to keep a check on the data showing production were made whenever and wherever special information was required.

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In addition to knowing the quantity of sulphur available, the location of the deposits, and the normal and current rate of production, it was necessary to know how much could be mined during different periods and how the deposits could be developed more expeditiously and more economically. There were also problems of transportation involving the moving of large quantities of ore without interfering with more urgent war needs and without using ships for importing foreign pyrites. There was also the very important problem of determining the quantity of sulphur material required for the war program as laid down by the Government—a program which was in a constant state of rearrangement owing to the need of balancing the demand for supplies against the producers' ability to furnish them. Then, too, there was the need of definite decisions as to the relative importance of all commodities, so that with a wide outlook encouragement or curtailment of any activity should be wisely applied and administered. These matters were handled by many different Government organizations and often the conclusions reached by one were not accepted by others, so that for a time there was a great deal of lost motion, misdirected activity, and absence of a clearly announced policy to be rigorously followed.

One of the earliest of the new organizations that among other things concerned itself with the sulphur and pyrites industry was the subcommittee on fertilizers of the Committee on Chemicals of the Advisory Committee of the Council of National Defense. This committee served for some time as an adviser, but it had little actual authority to compel acceptance of its decisions. In the later part of 1917 the Chemical Alliance was formed as an organization of the users and producers of various materials including sulphur and pyrites. Near the end of 1917 and in the beginning of 1918, most of the advisory boards were dissolved and the Chemical Alliance took over the work formerly done by the Committee on Chemicals. One section of the alliance was devoted to domestic pyrites and sulphur and another section to foreign pyrites.

The end of 1917 and the beginning of 1918 marked the establishment of several of the larger and more powerful Government war organizations, such as the War Trade, War Industries, and Shipping boards. The severe winter, which badly hampered the movement of commodities by rail, resulted in placing local embargoes on many commodities and later this resulted in forcing a decision as to the relative value or importance of the various articles in the war so that priority of transportation might be granted to them in the order of their importance. In February priorities were granted by the car-service section of the Division of Transportation of the United States Railroad Administration to pyrites and fertilizer materials in section G, class 2. The President's proclamation of February 26, 1918, effective March 20, 1918, under the authority conferred by the food-control act of August 10, 1917, put the fertilizer industry under license system. Pyrites, sulphur, and sulphuric acid, as well as the other fertilizer ingredients came under the provisions of this proclamation and licenses for these commodities were handled by the License Division of the United States Food Administration. Licenses, however, were not required for dealers whose gross sales amounted annually to less than $100,000.

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The serious inroads on shipping by the enemy's submarines and the need of all available ships for the transportation of troops and munitions resulted, late in January, 1918, in representation to the War Trade Board and the Shipping Board that the importation of Spanish pyrites could be considerably curtailed. Finally, in March, an agreement between the Government, the producers, and the consumers was reached, whereby licenses for only 125,000 tons of pyrites imported from overseas would be granted between April 1 and October 1. This quantity was only about a quarter of the usual imports from overseas in the same months of other years. This curtailment was to be put into effect gradually, so as to permit all necessary business adjustments, and the imports were to decrease from 40,000 tons in April to 10,000 tons in August and September. Not all of even this greatly decreased quantity of foreign ore was actually imported.

The withdrawal of large bodies of men under the draft began to be seriously felt by the pyrites industry in the beginning of 1918, and by March many of the pyrites properties in the eastern United States were showing an actual falling off in production. Various governmental agencies, notably the Department of Labor, took steps to remedy the general shortage of labor, but the pyrites mines continued to find it impossible to get or keep men in competition with the great constructional operations of the Government, which paid higher wages and were believed by many to give greater immunity from active military service. Failure to mine as much pyrites as might have been produced was caused by lack of labor, as is shown by the fact that 12 mines, which together reported a capacity of about 530,000 long tons a year, produced less than 240,000 tons in 1918 and stated that a loss of more than 175,000 tons for the year was due to shortage of labor.

In July the greatly increased demand for sulphur and sulphur ores by the Government, as well as by private concerns, and the difficulty of properly distributing the supplies on the overburdened railroads and in the few ships that were available caused the War Industries Board to assume control of the production and distribution of sulphur materials. In taking over this control the board acted through the commodity chief in charge of pyrites and sulphur. This officer was permitted to avail himself of any voluntary assistance he desired from consumers and producers but he was instructed that "in case any producer or consumer declines to abide by the decisions of the War Industries Board, commandeering orders will be issued when necessary." This officer accepted the cooperation of the committee on production, distribution, and control of sulphur-bearing materials of the Chemical Alliance, and thus brought closely together the Government, the producer, and the consumer in a relation that continued during the remainder of the war. Soon after the signing of the armistice the war boards began discontinuing their work, licenses and restrictions were gradually removed, and the industries made all efforts to get back to normal conditions.

Late in 1917 and early in 1918 it was found that the production of many of the minerals needed was not so great as was desired, and moves were made to stimulate their production. One of these moves was the introduction in Congress of bills authorizing the appointment of a mineral administrator. Hearings on these bills, at which the Government agencies, the producers, and the consumers ap-

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peared, were held throughout March, April, and May, and after various changes in the scope of the proposed legislation a bill was passed October 5, 1918, and the administration of the act was placed in charge of the Secretary of the Interior. As the armistice was signed in November, 1918, this legislation was too late to be of much benefit, because the problem had suddenly changed from one of stimulating production to one of absorbing the overproduction resulting from the close of hostilities. Many of the producers had undertaken to develop mineral properties at the urgent appeal of the Government for adequate supplies of needed mineral commodities, and some of them found that their markets were taken away and that they were facing substantial financial loss. After much discussion the conclusion was reached that reimbursement of claims of this sort was not authorized by the terms of the legislation that had already been enacted. The good faith of the Government, however, was involved in the stimulation of certain of the enterprises, and another bill to cover these cases was presented to Congress. This bill, which was passed and became effective March 3, 1919, permitted reimbursement for losses sustained by producers of certain minerals on presentation of satisfactory evidence that they had undertaken their enterprises in good faith through representations made by responsible Government officials. This act is administered by the War Minerals Relief Commission, which serves under the Secretary of the Interior. The only minerals coming under the provisions of this act are manganese, chromite, tungsten, and pyrites, and the only losses from which relief is provided are those incurred subsequent to April 6, 1917, and prior to November 12, 1918, and all claims were required to be in the hands of the commission within three months of the passage of the act.

SULPHUR.

DOMESTIC PRODUCTION.

Sulphur was reported to have been produced in 1918 by nine mines—one each in Louisiana, Wyoming, Colorado, and California, two in Nevada, and three in Texas. The two largest producers of sulphur are the Union Sulphur Co., whose mine is at Sulphur, Calcasieu Parish, La., and the Freeport Sulphur Co., whose mine is near Freeport, Brazoria County, Tex. These two companies continue to furnish about 99 per cent of the sulphur produced in the United States.

Two properties that had not been in operation in 1917 reported a small production in 1918. One of these properties is in Colusa County, Calif., and the other is in Culberson County, Tex. A mine in Park County, Wyo., that produced sulphur in 1917 was idle in 1918. The quantity of sulphur produced by the new mines was, however, less than that formerly produced by the Wyoming mine that was idle in 1918, so that stimulation through national need and war prices did not increase the production of the smaller companies. The two large mines, however, responded amply to the demand for more sulphur than ever before and fully lived up to their promise to meet the country's need; and these two mines met the call for sulphur without having to reduce their stocks—in fact, larger stocks of sulphur were on hand at the end than at the beginning of the

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year. The large immediately available supply represented by the stocks on hand was a constant insurance against any curtailment of the military program through shortage of sulphur. The value of this protection was especially evident in August, when a cyclone razed practically all the equipment above ground at the Union Sulphur Co.'s mine and stopped all production there for several days. In spite of this handicap, however, shipments were continued at almost the same monthly rate as during the preceding months. At no time did the company relax its efforts to produce sulphur and resort to drawing on its stocks. As a consequence, the damage done by the storm was remedied as quickly as possible and new construction was rushed so fast that, although the storm occurred August 5, the production from the mine for October was far above its monthly average for the year and was only a few hundred tons less than the greatest quantity produced in any month of the year.

Through the courtesy of the sulphur producers it is possible to publish statistics of the sulphur industry in the United States for the last 10 years. The information for 1915, 1916, and 1917 has not heretofore been published.

Sulphur produced and shipped in the United States, 1909–1918.[a]

Year.	Mined.	Shipped.		Year.	Mined.	Shipped.	
	Quantity (long tons).	Quantity (long tons).	Approximate value.		Quantity (long tons).	Quantity (long tons).	Approximate value.
1909	273,983	258,203	$4,782,000	1914	417,690	341,985	$6,214,000
1910	247,060	250,919	4,522,000	1915	520,582	293,803	4,959,000
1911	205,066	253,795	4,573,000	1916	649,683	766,835	12,246,000
1912	787,735	305,390	5,289,000	1917	1,134,412	1,120,378	23,987,000
1913	491,080	319,333	5,617,000	1918	1,353,525	1,266,709	27,868.000

[a] Revised figures.

The effect of the war on the production of sulphur as well as the changes in the importance of the industry is perhaps best shown by the graphic representation of the production from 1880 to 1918 in figure 60 (p. 363).

The statistics in this report are somewhat different from those formerly published by the Geological Survey, as certain records that have not heretofore been available and that proved to be more accurate than those used have been placed at the disposal of the Survey. This diagram shows that from 1880 to 1901 the sulphur produced in the United States was less than 8,000 long tons a year and for eight of those years was less than 1,000 tons a year. From 1902 to 1906 there was a great increase in production, which in 1906 reached almost 300,000 tons. From 1906 to 1916 the production fluctuated within rather wide limits, and averaged about 400,000 tons a year. In 1917 the production (1,100,000 tons) was nearly double the great output of 1916, but even that high mark was exceeded by more than 200,000 tons in 1918. The production for 1918 doubtless marks a limit that will not be reached again in many years.

Statistics of the production of sulphur by the rest of the world in 1918 are not yet available, but the output in the United States alone in 1918 was 65 per cent more than the total output of the world in 1913. In 1913 Italy and the United States produced almost the same quantity of sulphur, but since that year the production from Italy has decreased, so that the relative standing of the two countries is now very different. The only other country which made a large output of sulphur was Japan, and in 1913 that country produced only 8 per cent

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of the world's sulphur. So far as has been learned the sulphur industry of Japan has not increased to any marked extent during the last three years; in fact, it is commonly reported that in spite of the greatly increased manufacture of sulphuric acid in that kingdom, its output of sulphur has been falling off.

IMPORTS.

The quantity of foreign crude sulphur imported into the United States in 1918 was insignificant, amounting to only 55 tons. The need of restricting the use of shipping to transporting only the most essential war materials doubtless helped to decrease the imports, but probably a more effective cause of the decrease was that many of our Allies used sulphur from Italy and other foreign deposits for their own war needs. Inasmuch as the domestic supply of sulphur was

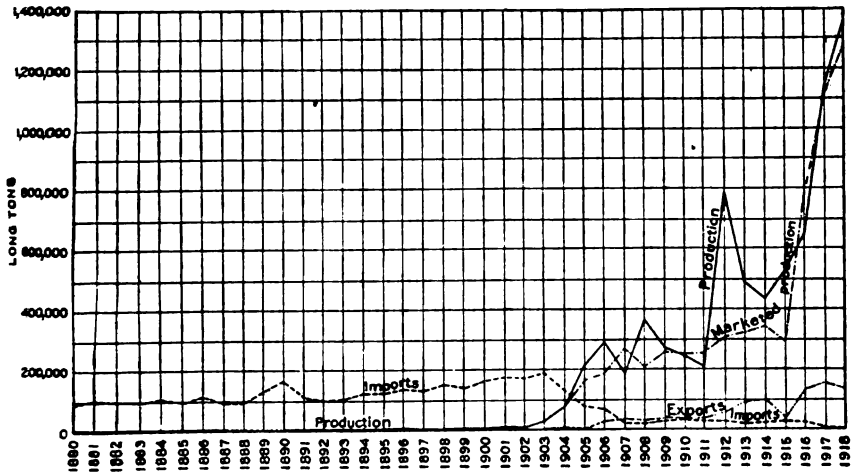

FIGURE 60.—Domestic production, imports, and exports of sulphur, 1880–1918.

adequate for the United States, much unnecessary cross haul was thus avoided.

The data in the following table were furnished by the Bureau of Foreign and Domestic Commerce.

Crude sulphur imported into the United States in 1918.

Country.	Port of entry.	Quantity (long tons).	Value.
Japan	Washington State	50	.....
	Hawaii	1	.....
Mexico	New York City	4	.....
		55	$1,092

The total value ($1,692) of the crude sulphur imported in 1918 was equivalent to about $31 a ton, or about $10 a ton higher than in 1917. In addition to the crude sulphur, about 27 tons of lac or precipitated sulphur, valued at $7,850, was imported in 1918 by the United States.

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The imports of sulphur by the United States from 1880 to 1918, inclusive, are presented in figure 60, which shows that from 1880 to 1903 the annual imports averaged not less than 100,000 long tons. The minimum quantity imported was 87,837 tons in 1880, and the maximum was 188,990 tons in 1903. In the period of rapid increase in the domestic production from an average of 8,000 tons in 1901 to almost 300,000 tons in 1906 the demand for foreign sulphur began to lessen, and the imports decreased to about 20,000 tons. Since 1907 the imports have never exceeded 30,000 tons a year and have averaged about 20,000 tons. The smallest quantity imported in any year (55 tons) was in 1918.

EXPORTS.

The sulphur exported in 1918, according to the Bureau of Foreign and Domestic Commerce, amounted to 131,092 long tons, valued at $3,626,638, or an average of $27.66 a ton. This quantity was about 20,000 tons less than was exported in 1917, but was greater than that exported in any other year. The relation of the quantity of sulphur produced, exported, and imported is graphically shown in figure 60. Sulphur was first exported by the United States in 1904. In 1907, for the first time, the exports exceeded the imports. From 1906 to 1911, inclusive, the exports averaged roughly 30,000 tons a year. In 1912, 1913, and 1914 the exports increased successively, until in 1914 they amounted to nearly 100,000 tons, but in 1915 there was a decided decrease to less than 40,000 tons. This was followed by the enormous increase in exports in 1916, 1917, and 1918.

The greatest quantity of sulphur exported in any single month in 1918 was in February and was somewhat over 15,000 tons. From February to May, and again in November, the monthly export was about 14,000 tons. In January, from July to September, and in December the exports averaged from 6,000 to 8,000 tons, and in June and October about 11,000 tons. The following table shows the exports of crude sulphur from the United States to different parts of the world in 1918 and the customs districts from which it was cleared. Although the customs districts are distributed around the entire border of the country, practically all the sulphur exported was produced by the two large mines in Louisiana and Texas.

Sulphur exported from the United States in 1918, in long tons.

Destination.	Ports of clearance.						
	New York City.	Maine, New Hampshire, Massachusetts, and Vermont.	St. Lawrence, Buffalo, and Michigan.	Dakota, Duluth, Montana, Idaho, and Washington.	California and Arizona.	Texas and Louisiana.	Total.
North America	825	7,710	79,447	12,715	290	6,280	107,267
South America	3,092	.....	.....	.....	33	120	3,245
Europe	4,343	.....	.....	.....	.....	13,996	18,339
Asia	26	.....	.....	2	343	.....	371
Africa	470	.....	.....	.....	.....	1,400	1,870
	8,756	7,710	79,447	12,717	666	21,796	131,092

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The exports of sulphur from the United States to different countries in the five years from 1914 to 1918, inclusive, are shown diagrammatically in figure 61.

There was a decrease in 1918 in the exports of sulphur to all the countries except those in North America. Of the 107,267 tons exported to North American countries, 99,927 tons were sent to Canada, 2,519 tons to Mexico, and 4,333 tons to Cuba. Of the 18,339 tons exported to European countries, 7,146 tons were sent to England, 4,850 tons to France, 4,253 tons to Portugal, and 2,000 tons to Norway; of the 3,245 tons exported to South American countries, 2,326 tons were sent to Brazil and 553 tons to Argentina; of the 1,870 tons exported to Africa, 1,676 tons were sent to British South Africa; and of the 371 tons of sulphur credited as exported to Asia, 341 tons were sent to Australia.

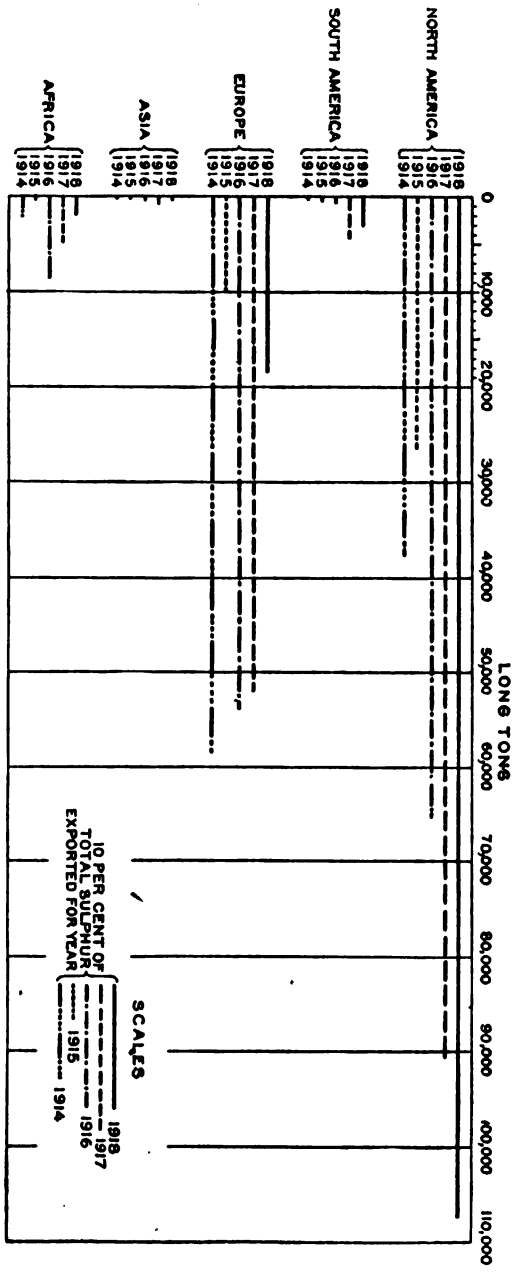

FIGURE 61.—Sulphur exported from the United States, 1914–1918.

CHARACTER OF DOMESTIC DEPOSITS.

At both the large mines the sulphur occurs under essentially similar conditions. From the surface to a depth of several hundred feet are unconsolidated sands and muds. Beneath the unconsolidated deposits is a limestone in places as much as 100 feet thick, locally known as the cap rock, because it covers the sulphur deposits. Next beneath the cap rock is limestone with some gypsum and large quantities of sulphur. Lower down the proportion of the limestone decreases, and in the next few hundred feet the beds are mainly

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gypsum, with some sulphur and a little limestone. Still lower down the rock is massive gypsum. This gypsum member is said to rest on beds of salt of unknown thickness. The rocks below the unconsolidated deposits are apparently folded so that the rock surface forms a dome. In fact, the slopes of the sides of the rock dome are in places more than 45°. The sulphur does not occur in massive beds but in stringers and lenses, which traverse the adjacent rocks irregularly.

The early attempts to mine the Louisiana deposit, which was the first to be discovered, were unsuccessful until the double problem of reaching the deposit and of extracting the sulphur was solved by Dr. Herman Frasch. The original Frasch patents having expired, the same general process is now being used both at the original locality and at Freeport, Tex. Briefly this process is as follows: Holes nearly a foot in diameter are bored to the deposit by rigs and drills similar to those used in boring for oil, and the sulphur, which liquefies at about 116° C., is melted by the introduction of superheated water. After the sulphur has melted and collected at the bottom of the hole, it is raised to the surface by the use of compressed air. The sulphur in the liquid state is piped to large bins, where on cooling it consolidates. The solid sulphur in the bins is blasted down by powder, picked up by steam shovels, and loaded into box cars for railroad shipment or on open gondola cars for transportation to the loading dock for ocean shipment.

The sulphur obtained is not further refined at the mines, but is sold with the guaranty that it is at least 99.5 per cent pure. It contains no arsenic or selenium. Usually not all the sulphur in the adjacent rocks is melted out by one well, and consequently the practice has been to abandon a well after a certain length of time and later to go back to the same general place and sink another well. The distance to which the steaming affects the rock varies greatly according to local conditions. In some places wells less than 50 feet apart show no interrelation, whereas in other places wells more than 1,000 feet apart show distinct intercommunication. Already several hundred wells have been sunk at each mine, but of these only four or five yield sulphur at a time. The number of wells in operation at a time is limited not only by the equipment required to furnish the necessary hot water but also by the necessity of avoiding the setting up of excessive pressures underground. The quantity of sulphur derived from individual wells differs considerably. The most productive wells are said to have yielded more than 100,000 tons of sulphur.

According to recently published statements by the Trade Commission[1] regarding the cost of producing sulphur at the two large sulphur mines, "the cost of the Freeport Co. in 1917 was $6.15 per ton; in 1918 it is estimated that increases will bring the cost up to not over $9.50 per ton. In the first part of 1917 the Union Co.'s costs were $5.73 per ton."

At all the other producing sulphur deposits the sulphur occurs in part at least at the surface and is mined by stripping or by subsurface drifting. The ore is then taken to retorts or furnaces, where it is heated so that the sulphur liquefies and runs out of the rock. The sulphur usually constitutes from 10 to 50 per cent of the ore,

[1] Official Bull., vol. 2, No. 348, p. 13, 1918.

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and although the ore can be mined at these places rather cheaply, the handling and further treatment required to free the sulphur from the worthless material is expensive. Furthermore, a good deal of the sulphur is not extracted by this rather crude method of treatment, and hence the difference between the original sulphur content of the ore and the quantity of sulphur recovered in practice is often very great.

Most of the companies producing small quantities of sulphur are developing localized deposits that seem to be more or less intimately connected with the dying out of volcanism or solfataric action. The richer parts of the deposit on a single property are therefore rather irregularly distributed and usually cover only a small area. The sulphur content is usually greatest in the surface portions, although in places the sulphur-bearing formation is reported to be as much as 40 feet thick.

SULPHUR DEPOSITS RECENTLY INVESTIGATED BY GEOLOGICAL SURVEY.

In the chapter on sulphur in Mineral Resources for 1916 all the known deposits of sulphur in the United States were described. In the similar chapter for 1917, a few additional sulphur localities were listed, among others one near Jemez Hot Springs, in New Mexico. Practically nothing was known regarding the value of this deposit as a source of sulphur, and accordingly Geologist George R. Mansfield was detailed to make an investigation of it. His report, which has already appeared in several of the technical papers, follows:

NEW MEXICO.

SULPHUR IN JEMEZ CANYON, SANDOVAL COUNTY.

By GEORGE R. MANSFIELD.

Small deposits of sulphur have long been locally known in Jemez Canyon, Sandoval County, N. Mex. Early in 1918 the suggestion was made that these deposits might be a source of commercial sulphur. Reconnaissance reports already available at the United States Geological Survey indicated that the deposits were probably of slight extent or value, but in order to obtain more detailed information a geologist was sent from the Survey to examine them. The examination confirmed the unfavorable reconnaissance report and showed that the deposits are not of commercial value.

The deposits occur at two places, one in the Canyon de San Diego grant, about 5 miles above Jemez Springs, nearly three-fourths of a mile below the forks of the creek; the other at Sulphur Springs, in the Baca location, about 14 miles above Jemez Springs. Inquiries at Jemez Springs elicited no information concerning any other deposits in the region comparable with these two. The nearest railroad points are Bernalillo and Albuquerque, on the Atchison, Topeka & Santa Fe Railway, about 45 and 60 miles, respectively, south of Jemez Springs, by the wagon road. The road for much of the way is heavy with sand.

San Diego deposit.—The sulphur ore at the deposit, which may be called the San Diego deposit, consists apparently of residual material

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from Carboniferous limestone leached by acidulated waters and permeated by sulphurous vapors, which have deposited free sulphur in the crevices and pores of the upper few feet of rock.

The sulphur-bearing mass is about 700 feet long and 150 feet wide, occupying a lenticular area of about 1 acre. Two smaller areas, 50 feet or less in diameter, were noted in branches of a small tributary canyon about three-fourths of a mile to the northwest. The writer spent nearly three days in mapping, exploring, and sampling this deposit in association with Linus Shields, superintendent of the Canyon de San Diego grant. In this exploration, six prospect cuts were dug, exposing fresh sections ranging in depth from 2 feet 1 inch to 13 feet 6 inches. From these cuts numerous measurements were made and 11 samples were obtained for analysis. The sulphur is irregularly deposited and is in a relatively thin deposit, measuring only 2 feet 4 inches to 3 feet 4 inches in thickness in four cuts in the more promising parts of the area. In one cut the deposit was not penetrated at a depth of 4 feet 2 inches. The sulphur ore contains from 15 to 39 per cent of free sulphur and from 6 to 8.5 per cent of sulphur combined as sulphate. The rock under the ore contains no free sulphur, but about the same percentage of sulphur combined as sulphate.

Deposit at Sulphur Springs.—The deposit at Sulphur Springs is similar, except that it occurs in rhyolite, a volcanic rock. The rocks at this locality are at some places still warm to the touch, and there are numerous vents in them from which hot acidulated waters and sulphurous vapors are now being emitted. Some of these vents are being utilized for the hot water and vapor baths that make Sulphur Springs a local health resort. The escaping vapors have deposited sulphur on the walls of the vents, lining them with beautiful acicular or stout yellow crystals.

One day was spent in the trip to Sulphur Springs, where the deposit occupies about 9 acres in a small basin eroded in the rhyolite. A number of low slopes between drainage lines are covered with white débris and some yellowish spots suggesting sulphur ore, the presence of which was confirmed by making small pits, but pits in other areas disclosed no sulphur.

Sixteen years ago M. S. Otero, former Delegate to Congress from New Mexico, built at Sulphur Springs a mill equipped with a boiler, engine, pump, and two retorts of about 1-ton capacity each, for producing sulphur. The retorts were filled with ore and steam under pressure of about 30 pounds was led into them and the melted sulphur was drawn off below. On the death of Mr. Otero, two years later, the mill was closed and the property passed into the hands of his sons. According to A. T. Otero, who furnished the above data regarding development, the ore treated ran about 60 per cent sulphur and the total production amounted to about 200,000 pounds, of which 150,000 pounds were sold at Albuquerque, the rest being sold in small lots to local purchasers.

The ore used by the mill had been taken from an entry, now caved, on a low ridge that forms the southeastern extension of the deposit. A shallow cut, 4 feet 10 inches long, made on the side of this tunnel, showed seams of good sulphur in cracks, but the material as a whole did not run so well and seemed poorer toward the bottom. The crushed and quartered sample representing the entire

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cut contained 31.85 per cent of free sulphur and 2.09 per cent of sulphur combined as sulphates.

All the sulphur at Sulphur Springs was apparently deposited in vents, cracks, and pores within a few feet or a few inches of the surface. The available sulphur in this area is apparently not large in quantity and is irregularly distributed.

About 2 miles above Sulphur Springs and at several places in Jemez Canyon between Sulphur Springs and the San Diego deposit, hot springs or leached rocks indicate similarly active waters and vapors on a smaller scale. Hot sulphureted water occurs at Jemez Springs. These phenomena occur in a zone more than 15 miles in length along the general line of Jemez Canyon, and suggest the occurrence of a deep fracture or group of fractures in the earth's crust along which acidulated waters and sulphurous vapors have risen here and there and deposited sulphur. No evidence was obtained that the deposits are connected with one another.

Conclusions.—The examination led to the following conclusions: (1) The deposits are local and were formed independently along one or more deep fractures in the earth's crust; (2) the San Diego deposit covers about 1 acre, and the Sulphur Springs deposit covers 9 acres, though it includes numerous barren areas; (3) the sulphur ore is irregularly distributed and is relatively thin, being only 2 feet 4 inches thick at four measured cuts; (4) the quantity of available sulphur is too small to be of commercial importance, especially in view of the inaccessibility of the deposits.

ALASKA.

Deposits of sulphur have long been known in the vicinity of several of the volcanoes of the Aleutian Islands and the Alaska Peninsula. Several of these deposits were noted in the chapter on sulphur in Mineral Resources for 1916. During the summer of 1917 the deposits on Unalaska and Akun islands and near Stepovak Bay, Alaska Peninsula, were visited by A. G. Maddren, of the United States Geological Survey. A complete report[1] of his observations has been prepared, but the following summary is quoted from a preliminary announcement of the investigation and its results.[2]

The examination showed that although there is some sulphur at each place examined there is little probability that any of the deposits can be profitably mined at present or in the immediate future, for they are not of large area, most of them are probably shallow and contain only disseminated sulphur, supplies and labor are not obtainable near the deposits, the open season is short, the work of transporting the sulphur from the mines to the ships would be difficult, and the haul to the larger markets would be long. However, these deposits form part of America's sulphur reserves, and similar deposits undoubtedly occur at many other places in the volcanic belt of southwestern Alaska. When material and labor are more easily and cheaply obtainable, when transportation is cheaper, and when the demand for sulphur on the Pacific coast is larger, the sulphur deposits in Alaska can doubtless be mined profitably. The area within which workable deposits of sulphur may be found in Alaska is large and most of it is unexplored, so the place at which sulphur can be first and most profitably mined is not certainly known.

Sulphur claims have been staked on deposits in the crater of Makushin Volcano, on Unalaska Island; on Akun Island; and near Stepovak Bay. No sul-

[1] Maddren, A. G., Sulphur deposits and beach placers of southwestern Alaska: U. S. Geol. Survey Bull. 692–E, 1919.

[2] U. S. Geol. Survey (unsigned), Sulphur deposits of Alaska: U. S. Geol. Survey Press Bull. 372, July, 1918.

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phur has yet been marketed from these deposits, but during the last year they have attracted the attention of prospective investors with a view to their exploitation. Unalaska and Akun Islands are near the east end of the Aleutian Islands, in latitude 54° N., longitude 166° W., about 1,750 miles from Puget Sound. Stepovak Bay is on the south coast of Alaska Peninsula, in latitude 55° 50′ N., longitude 159° 40′ W., about 1,600 miles from Puget Sound.

The sulphur deposit at Makushin Volcano is about 12 miles west of Dutch Harbor, or 5 or 6 miles north of Makushin Bay. It is about 5,500 feet above sea level, in the only part of the crater that appears to be perfectly bare of snow and ice. This bare area covers 20 to 30 acres. The surface here consists of loose, porous, disintegrated, and decayed lava. In the floor of the crater there are many cracks, pits, and other openings from which hot volcanic vapors issue constantly. In several auger holes drilled in the cooler parts of the earth hot sulphurous vapor was tapped at depths of 4 to 8 feet. The ground is so hot that deposits of sulphur are not at all likely to be formed except near the surface.

The deposit includes a richer surface zone, 1 to 2 feet thick, which forms a crust, because of the sulphur deposited in it, and a subsoil zone which consists in greater part of moist, hot, porous, decomposed material, in which a small quantity of sulphur is disseminated as grains and blebs to a depth at some places of at least 16 feet.

The sulphur is very irregularly distributed, even in the crusty surface zone. Although pure sulphur occurs in masses in some of the dormant and semidormant vents, it does not extend very far down these openings. Some of these masses may include several cubic feet of apparently pure sulphur that could be mined by careful hand methods, but the aggregate space thus occupied by sulphur in the crevices and vents is relatively small, for although a few of the crevices are 10 to 12 inches wide, most of them are not more than 2 or 3 inches wide. The thickness of the sulphur-bearing crust between the crevices averages about 12 inches, although in some places it is as much as 2 feet. This crust, however, is not composed of solid sulphur, although in some places the upper 6 inches of it is chiefly sulphur. In general the lower 6 inches of a 12-inch section of the crust includes a large proportion of earth, and at many places the upper 6 inches of the deposit is also decidedly earthy.

Of the 20 or 30 acres of bare ground described probably not more than 5 acres, situated in its southern part, contains a good grade of sulphur-bearing material, and only a still smaller area contains high-grade material, even in the surface crust.

The high-grade sulphur at the open vents is about 98 to 99 per cent pure and includes about 5 per cent of the whole of the surface material. About 70 per cent of the surface material to a depth of 1 or 2 feet contains 86.3 to 89.6 per cent of sulphur, as shown by analyses of four specimens, the average content of the specimens being about 88 per cent. The average sulphur content of the surface material to a depth of 1 to 2 feet is therefore about 60 per cent. If the weight of the dried material is about 70 pounds per cubic foot (the weight indicated by the specific gravity of what was assumed to be a representative sample), the 5 acres of better ground should contain about 1,800 tons of sulphur per acre within 2 feet of the surface.

It is difficult to make even a rough estimate of the sulphur content of the remainder of the deposit, especially of the earthy part beneath the surface crust. This material is not of uniform thickness, and the quantity of sulphur that is disseminated through it is unknown. Five samples taken on the southwestern flank of the deposit from depths of about 4, 8, 10, 12, and 16 feet contain 47, 29.8, 14.7, 13.8 and 9.5 per cent of sulphur, respectively, averaging about 23 per cent. If this average holds throughout the deposit, the zone from 2 to 16 feet below the surface should contain from 716 tons of sulphur per foot per acre at a depth of 4 feet to 145 tons per foot per acre at a depth of 16 feet, or a total for the entire 14-foot zone of 4,900 tons per acre.

The sulphur-bearing area on Akun Island, on which mining claims have been located, is 1,300 to 1,500 feet above sea level and lies on the flanks of a rugged ridge about 2 miles from the shore of Lost Harbor. The sulphur-bearing area includes 15 to 20 acres, but the best part of the deposit includes only about 5 acres.

The sulphur in this deposit consists chiefly of crystalline incrustations one-sixteenth to one-eighth of an inch thick on the walls of narrow crevices and small cavities in the porous earthy surface zone. Some sulphur is also disseminated through the decomposed material, but there are practically no bodies of solid sulphur in any part of the deposit.

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Most of the sulphur in this deposit occurs in the porous earthy mantle within 1 to 4 feet of the surface. The average thickness of this mantle is believed to be about 2 feet. Two samples, one taken at the surface and the other at a depth of 4 feet, contained 55.5 and 22.8 per cent of sulphur, respectively. If the average thickness of the sulphur-bearing surface mantle is 2 feet, and if its average sulphur content is 40 per cent, it should contain 1,200 tons of sulphur per acre.

Stepovak Bay is on the south shore of Alaska Peninsula in latitude 56° N., longitude 160° W. The only large sulphur deposit reported in the vicinity is about 7 miles northwest of the head of the bay at an altitude of 3,000 feet. This deposit was not visited, but a glacial moraine that extends coastward from the locality consists largely of sulphur-bearing rock, which was probably derived from it.

The sulphur-bearing rock in the morainic deposits consists of porous volcanic breccia containing compact crystalline sulphur in its interstices and in the vesicles of its constituent fragments. Some specimens of the breccia probably contain 20 per cent of sulphur in masses one-eighth inch to an inch long. The sulphur is finely disseminated through much of the breccia, of which it probably forms not more than 5 or 10 per cent. Parts of the body of the moraine may contain 10 per cent of sulphur, but larger parts of it are practically barren. The material in the moraine is probably poorer in sulphur than the bed from which it came. Some of the sulphur-bearing boulders are 30 to 40 feet thick, and thus indicate the minimum thickness of the bed or beds from which they were derived. The abundance of the sulphur-bearing material in the moraine also indicates that the original deposit was large.

PYRITES.

DOMESTIC PRODUCTION.

The domestic production of pyrites in 1918, as shown in the accompanying table, was 464,494 long tons, valued at $2,644,515, a decrease of about 18,000 long tons in quantity but an increase in value of about $50,000 as compared with the production in 1917. The consumption of pyritic ores—that is, the domestic production plus imports—amounted to about 960,000 long tons and was less even than the imports in 1917, or nearly 490,000 less tons than the consumption in that year. The decrease is largely attributable to the great falling off in imports. The following table shows the production of pyrites by the different States in 1918 so far as it may be given without disclosing confidential data regarding the production of individual companies. This production was reported by 64 mines in 15 States, or 10 mines more than in 1917.

Pyrites produced in the United States in 1918, by States.

State.	Lump.		Fines.		Total.	
	Quantity (long tons).	Value.	Quantity (long tons).	Value.	Quantity (long tons).	Value.
California	(a)	(a)	(a)	(a)	111,861	$501,541
Colorado	2,947	$6,935	15,870	$108,777	18,817	115,712
Georgia	9,334	79,526	21,981	189,271	31,315	268,797
Illinois	(a)	(a)	(a)	(a)	24,369	85,659
Missouri	(a)	(a)	(a)	(a)	7,674	69,202
New York	(a)	(a)	(a)	(a)	63,982	422,958
Ohio	9,845	40,215	.....	.....	9,845	40,215
Virginia	85,359	233,572	58,068	607,605	143,427	841,177
Other States [b]	17,640	138,549	35,564	160,705	53,204	299,254
	[c] 199,472	[c] 794,117	[c] 265,022	[c] 1,850,398	464,494	2,644,515

[a] Output of lump and fines are not shown separately, as there are less than three producers of one or the other.

[b] Includes Alabama, Kentucky, Pennsylvania, South Carolina, South Dakota, Tennessee, and Wisconsin.

[c] Includes quantity produced in States whose individual output may not be shown separately.

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Virginia continued to be the leading State in the production of pyrites, but it produced about 27,000 tons less in 1918 than in 1917. California ranked second and produced about 4,000 tons less than in 1917. California and Virginia together furnish more than half the pyrites produced in this country. New York, the third State, and Georgia, the fourth, each showed in 1918 an increase of a few thousand tons over their respective outputs in 1917.

Of the total quantity of pyrites produced, 199,472 tons were reported to be lump and 265,022 tons were fines or concentrates. The total sulphur content of the lump ore was 74,504 tons, or an average of slightly more than 37 per cent of sulphur, and that of the fines or concentrates was 110,984 tons, or an average of about 42 per cent of sulphur. The value of the lump ore was $794,117, and of the fines or concentrates $1,850,398; the average price of the lump ore was therefore $3.98 a ton and that of the fines $7 a ton. According

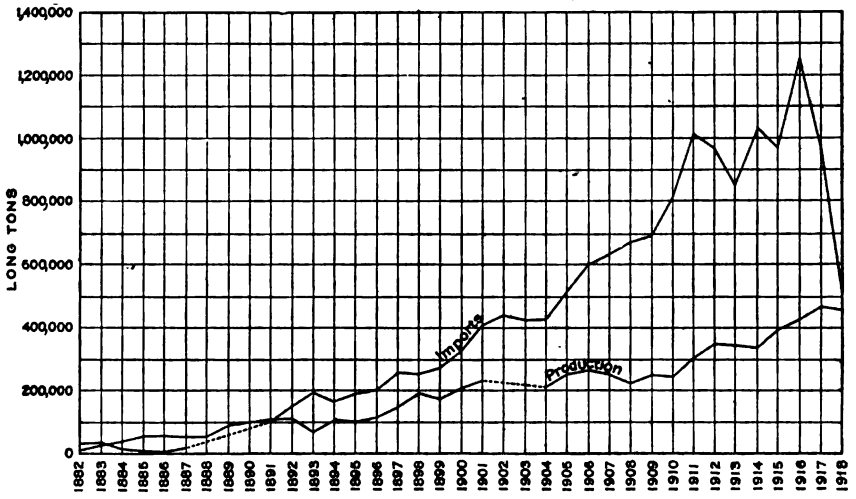

FIGURE 62.—Domestic production and imports of pyrites, 1882–1918.

to these figures the average price per unit of sulphur in the lump ore was about 10 cents and in the fines or concentrates about 16 cents.

The record of the production of pyrites from 1882 to 1918, inclusive, is graphically shown in figure 62.

Data regarding the production of pyrites in 1902 and 1903 are not available, so that the portion of the curve for these years has been projected as a straight line between the known quantities for 1901 and 1904. On the whole, there has been a rather regular increase in production, the fluctuations from year to year seldom being as much as 50,000 tons. From 1884 to 1891 the domestic production appears to have exceeded the imports; in the other years it was less.

Pyrites produced in the United States, 1909–1918.

Year.	Quantity (long tons).	Value.	Year.	Quantity (long tons).	Value.
1909	247,070	$1,028,157	1914	336,662	$1,283,346
1910	241,612	977,978	1915	394,124	1,674,933
1911	301,458	1,164,871	1916	[a] 439,132	[a] 2,038,002
1912	350,928	1,334,259	1917	[a] 482,662	[a] 2,593,035
1913	341,338	1,286,084	1918	464,494	2,644,515

[a] Revised figures.

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IMPORTS.

The imports of pyrites showed a notable decrease in 1918 from those in 1917. This decrease was due in part to the difficulty of obtaining ships for the transportation of ore from Spain, but was very largely attributable to the action of the Government boards in issuing licenses for only a small part of the usual tonnage. The total imports of pyrites in 1918 amounted to 498,786 tons, less than in any other year since 1905. The annual imports from 1882 to 1918 are shown graphically in figure 62. The imports in 1888–1890, however, are not definitely known, and this part of the curve is projected as a straight line between the known quantities for 1887 and 1891.

The data for the following table were furnished by the Bureau of Foreign and Domestic Commerce:

Imports of sulphur ore as pyrites, containing more than 25 per cent of sulphur, in 1918, by countries and districts of entry.

Country exporting.	1918		Districts of entry.	1918	
	Quantity (long tons).	Value.		Quantity (long tons).	Value.
			Buffalo	45,764	$214,807
			Chicago	72,135	334,227
			Duluth-Superior	12	250
Canada	221,612	$939,143	Michigan	451	1,889
			Ohio	74,966	318,158
			St. Lawrence	30	300
			Vermont	28,084	67,812
			New York	170	1,700
England	1,959	6,638	New York	1,959	6,638
France	4,566	67,150	Philadelphia	4,566	67,150
			Florida	17,263	75,521
			Georgia	26,648	108,507
			Maryland	36,853	205,615
			Massachusetts	8,693	28,576
Spain	270,649	1,754,517	New Orleans	3,212	11,047
			New York	62,756	412,253
			Philadelphia	78,543	748,854
			South Carolina	26,269	100,426
			Virginia	10,412	63,718
	498,786	2,767,448		498,786	2,767,448

A comparison of this total with the similar one for 1917 shows that imports from Canada increased nearly 7,500 tons in 1918 and that the imports from Spain decreased about 477,000 tons. The quantity of pyrites imported from Canada was much less than had been predicted and the falling off was doubtless due to the abundance of domestic crude sulphur available in the United States. The pyrites reported to have been imported from France and England is believed to have been produced in and shipped from some other country and then reshipped and thus credited to these countries that as a rule do not produce pyrites for shipment.

The value of the imported pyritic ore as stated by the Bureau of Foreign and Domestic Commerce was $2,767,448, an average price of $5.55 a ton. The average price of the ore imported from Canada was less than $4.25 a ton. The average price of the Spanish ore was nearly $6.50 a ton. Some of the difference in price is warranted by the generally high sulphur content of the Spanish ore, but some of the difference is caused by the unwillingness of the users of pyrites to modify their former practice and accept any substitute if Spanish ore is obtainable even at an extra cost.

The cessation of hostilities has had a considerable effect on increasing the imports of Spanish ore and this effect will doubtless be even greater in the future unless tariff or other governmental restric-

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tions are placed on the free movement of this commodity. Licenses are no longer required, and the shortage of ships and the availability of crude sulphur are the main obstructions to a resumption of the former rate of importation. Recent quotations in the technical press (April and May, 1919) show that Spanish pyrites are quoted at about 20 cents a unit c. i. f. New York or any of the Atlantic ports.

CHARACTER OF DOMESTIC DEPOSITS.

The iron sulphides are very common minerals, being found in all parts of the country and in almost all kinds of rocks. In order to be of value, however, they must occur in deposits capable of yielding a considerable quantity relatively free from worthless material and must be so situated that they can be cheaply mined and transported to market.

In the United States, there are four main areas in which pyrites is so abundant that deposits of pyrites may be sought in them with some promise of success. These areas, enumerated from east to west, are the Appalachian Mountain region, where pyrites occurs in lenses associated with schists and crystalline rocks; the interior States, where it is mainly associated with coal beds; the Rocky Mountain States, where, in places, it occurs in numerous veins and lenses often mixed with sulphides of copper, lead, and zinc; and the Coast Ranges, where it usually occurs in lenses more or less intimately associated with igneous rocks.

More than three-quarters of the domestic and imported pyrites consumed in the United States is used in the region east of Mississippi River. As a consequence, although there are enormous deposits of pyrites in the western part of the country, most of the deposits in the Rocky Mountain States and farther west can not be profitably utilized under present conditions.

In most coal mines pyrites is separated from the coal when the coal is prepared for market, and at a few mines this pyrites is saved and sold. In general, it is discarded as waste, several hundred thousand tons being thus discarded every year. Usually, however, its recovery would cost more than it is worth, for if pyrites is separated from the coal underground it requires special sorting and when it is hoisted to the surface it interrupts and delays the hoisting of the coal. In some districts attempts to recover the pyrites contained in the waste from the coal washeries have been made, but usually the quantity of this material from any one mine is not sufficiently great to pay for the installation of the necessary equipment. Furthermore, the manufacturers of sulphuric acid—the main users of pyrites—have not been disposed to purchase the pyrites recovered from coal. Some of this reluctance is due to the fact that pyrites containing carbon (coal) is likely to take fire easily, makes a dark-colored acid, requires the use of more niter, and decreases the capacity of the acid plant. Extensive experiments under the direction of E. A. Holbrook[1] have shown that by the use of appropriate ore-dressing treatment the pyrites can be cleaned so thoroughly of adhering coal as to remove many of these objections. The unwillingness to use pyrites from coal, or "coal brasses," is clearly reflected in the low price paid for pyrites from this source. According to the table on page 371 the

[1] Holbrook, E. A., The utilization of pyrites occurring in Illinois bituminous coal: Illinois Univ. Eng. Exper. Sta., Aug. 20, 1917.

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value per ton of pyrites produced in Illinois was $3.52 and of that produced in Ohio, $4.08. All of this pyrites was obtained from coal deposits. These prices may be contrasted with the prices paid for pyrites that was not derived from coal deposits, which were $5.86 a ton in Virginia, $6.61 a ton in New York, and $8.58 a ton in Georgia.

The chapter on sulphur, pyrites, and sulphuric acid in Mineral Resources for 1917 contained a fairly complete statement regarding the deposits of pyrites that were being mined or appeared likely to be developed. In these descriptions the main facts regarding the location of the different deposits, the size and extent of the ore bodies and their geology, and the general tenor of the ore were given as fully as the data available permitted. That report should therefore be consulted by those who desire further information regarding the type of deposits of pyrites in any part of the country. Not only does that report furnish a summary statement regarding the various deposits but it also gives references to published reports on special areas or deposits from which still more detailed information may be obtained.

Since the chapter of Mineral Resources noted above was published, a bulletin on the deposits of pyrites in Georgia has been issued by the Geological Survey of that State.[1] That bulletin gives much detailed information regarding the deposits of pyrites in Georgia and is illustrated by diagrams, maps, and pictures which show graphically many of the significant facts regarding the deposits. According to that report, the deposits of pyrites show a great variation in character of ore and associated rocks. There are four main types—metamorphosed pyrite veins, generally associated with the so-called Roan gneiss; limestone replacement; pyrrhotite veins; and disseminated deposits in basic rocks. Deposits of the first two types are the only ones that are known to be of commercial value.

USE IN SULPHURIC ACID INDUSTRY.

The use of pyrites and sulphur is so closely related to the production of sulphuric acid and that acid enters so largely into all industries that for the last seven years it has been the practice of the Geological Survey to collect statistics of the production of sulphuric acid. So many of the new war organizations, however, entered this field, and so many data were gathered, and the producers were engaged in filling in so many questionnaires that the Geological Survey abandoned its collection of statistics relating to this industry. It is felt, however, that information regarding the sulphuric acid industry is so important in its relation to the sulphur and pyrites industries that the following quotation of the published statement on the subject by A. E. Wells,[2] of the Bureau of Mines, who also served as a member of the War Industries Board, is given:

> On January 1 of this year [1918] the total manufacturing capacity of the country for acid was 427,000 tons per month (basis 100 per cent H_2SO_4), or 8,200,000 tons per year (basis 50° B.), of which 29 per cent was at contact acid plants.
>
> On November 1 of this year the total manufacturing capacity of the country was 500,000 tons per month (basis 100 per cent H_2SO_4), or 9,600,000 tons per

[1] Shearer, H. K., and Hull, J. P. D., Pyrite deposits of Georgia: Georgia Geol. Survey Bull. 33, 229 pp., 1918.

[2] Wells, A. E., Present sulphuric-acid capacity and estimates of requirements for 1919: Committee on Fertilizers of Chemical Alliance Weekly Bull. 82, Dec. 21, 1918.

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year (basis 50° B.). Of this total capacity 40 per cent was at contact acid plants.

This capacity was divided among (1) Government, (2) explosives companies, (3) all others, including commercial manufacturers, by-product manufacturers, etc., as follows:

	Expressed as tons per month (100 per cent H_2SO_4).	Expressed as tons per year (50° B.).
(1) At Government plants	54,000	1,040,000
(2) At plants of explosive manufacturers	58,000	1,120,000
(3) All others	388,000	7,440,000
	500,000	9,600,000

Inasmuch as the acid market conditions in the intermountain and Pacific coast districts are quite distinct from those in the East, and as there has been brought about very little, if any, disturbance in those districts, except for possibly some slight disturbance in the San Francisco district, it is not necessary to include the figures for those districts in the discussions regarding eastern conditions.

The total capacity east of the Mississippi River, and also including the plant at Argentine, Kans., and the plants in Louisiana and Arkansas, is as follows:

	Tons per month (as 100 per cent H_2SO_4).
(1) At Government plants	54,000
(2) At plants of explosives companies	50,000
(3) All others	350,000
	454,000

If we assume that the Government plants and the contact plants, which were built by the explosives companies primarily to supply acid for munitions explosives, are not operated in 1919 or, if operated at all, the production will be utilized only for munitions and thus will not be placed on the market, there remains a total capacity to be considered in the eastern part of the United States amounting to 365,000 tons per month (basis 100 per cent H_2SO_4), or 7,000,000 tons per year (basis 50° B.).

During the first nine months of 1918 the actual rate of production was only about 90 per cent of the rated maximum capacity, although many plants were operating much above the rated capacities. Therefore, it is fair to conclude that the probable maximum output from these plants during the year 1919 can not be greater than 90 per cent of the rated capacity, or, in other words, the maximum output could be only about 328,000 tons per month (basis 100 per cent H_2SO_4), or 6,300,000 tons per year (basis 50° B.).

During the months of June, July, and August, 1918, the following industries in the eastern part of the United States consumed approximately the following tonnage of acid:

	Tons per month (basis 100 per cent H_2SO_4).
1. Domestic explosives	7,500
2. Fertilizers	109,400
3. Chemicals and drugs, including nitric acid, hydrochloric acid, ammonium sulphate	37,600
4. Oil refining	28,700
5. Steel pickling and galvanizing	36,200
6. Fabrics, textiles, tanning, rubber, paper, bleaching	5,100
7. Paints, lithopone, dyes, glue, glycerine, alcohol	6,200
8. Storage batteries, metallurgical work	4,700
9. Miscellaneous and unknown	4,600
	[1] 240,000

[1] Or 4,600,000 tons per year (basis 50° B.).

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It is believed that the consumption of acid in the various industries during the period as given above offers a better basis for estimating the future consumption during 1919 than any reference to the figures of 1914. However, it may be stated by way of comparison that in the eastern half of the United States there were consumed in 1914 about 3,500,000 tons of acid (basis 50° B.), according to the figures compiled by the United States Geological Survey. From these figures, it is evident that between the years 1914 and 1918 there was an increase in the requirements of acid for industries, other than munitions explosives, amounting to about 1,000,000 (basis 50° B.). The consumption of acid for fertilizers will undoubtedly be greater in 1919 than in 1918, and will probably average at least 130,000 tons per month (basis 100 per cent H_2SO_4), or 2,500,000 tons per year (basis 50° B.). Thus, with general business conditions favorable, the average monthly consumption of acid in the above industries in the eastern part of the country during the year 1919 should not be less than 260,000 tons per month (basis 100 per cent H_2SO_4), or 5,000,000 tons per year (basis 50° B.). This would require operating all the plants at about 71 per cent of the rated maximum capacity, if the business was distributed over the district proportionately to the manufacturing capacity in the various districts. As a matter of fact, the southern fertilizer plants will probably operate to full capacity, while plants in Boston, New York, Philadelphia, and Baltimore districts may have to average less than 70 per cent of the rated capacity.

The production and consumption of acid in the western half of the United States will probably be about 500,000 tons per year (basis 50° B.), so that the total production for the whole country will be about 5,500,000 tons in 1919.

A discussion primarily of the prices of mineral acids, prepared by H. L. Lewenberg,[1] gives much information not only concerning the sulphuric acid industry but incidentally concerning the supplies of raw materials from which the acid is made. Among other significant statements contained in this report the following table showing the quantity of 50° Baumé sulphuric acid produced from the various sulphur materials for 1918 as estimated in the summer of 1918 is of particular interest because of its bearing on the sulphur and pyrites industry:

	Tons of 50° Baumé acid produced.
Sulphur	4,270,000
Domestic pyrites	1,150,000
Zinc ore fumes	900,000
Copper ore fumes	800,000
Spanish pyrites	600,000
Canadian pyrites	480,000
	8,200,000

The report by Mr. Lewenberg contains a tabulated statement and a chart showing graphically the relative prices of sulphur and pyrites, by months, from January, 1913, to December, 1914, the average quoted price for July, 1913, to June, 1914, being taken as 100 per cent.

[1] Lewenberg, H. L., Prices of mineral acids: War Industries Board Bull. 45, pp. 3–18, 1919.

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SILICA (QUARTZ).

By FRANK J. KATZ.

INTRODUCTION.

Silica (SiO_2), which is commonly known as quartz or flint, occurs abundantly throughout the United States in deposits of commercial importance in many different forms—as vein quartz, as a constituent of pegmatites, as sand, sandstone, quartzite, novaculite, flint, or chert, and as tripoli and diatomaceous (infusorial) earth. In some of its natural forms, such as rose, smoky, and amethystine quartz, it has value as gem material. This chapter deals with silica of all kinds except gem quartz, silica used for making glass, and silica used in the form of sand, gravel, and crushed material for building, for concrete and mortar, for foundry and furnace work, and for cutting and grinding stone. Such material as is not here included is either gem material or sand, is commercially so designated, and is therefore considered in other chapters of Mineral Resources. Tripoli and diatomaceous earth are to a large extent consumed as abrasives and are considered in the chapter on abrasive materials.

USES.

Silica (quartz) as considered in this chapter is used for many purposes, principally in the manufacture of pottery, paints, and scouring soaps, as a wood filler, as a polisher, as foundry mold wash in metallurgical and chemical processes, and in small quantities for cosmetics, dentifrices, and numerous other minor uses. In the pottery industry, where it is generally called flint, silica is used in the body of the ware to diminish shrinkage, and is also used in glazes. Silica for use in pottery should contain less than 0.5 per cent of iron-bearing minerals. Manufacturers of paint use considerable quantities of very finely ground silica, which forms as much as one-third of the total pigment in some paints. For certain purposes finely ground crystalline material is superior in paints to other materials because of the angularity of the grains, which makes them adhere more firmly to the article painted and after wear affords a good surface for repainting. The same angularity makes artificially comminuted crystalline quartz superior to natural sand for use in wood fillers. For soaps and polishing powders ground material is preferred to natural sand on account of its whiteness and angularity. For all these purposes large quantities of pure quartz sand and sandstone are finely ground and yield a product fully equal to that obtained by grinding massive crystalline quartz.

Quartz crushed and graded to various sizes is used in making sandpaper and sand belts, as a scouring agent, for "frosting" glass with sand-blast apparatus, and for other purposes. Blocks of massive quartz and quartzite are used in the chemical industry as a filler for acid towers and as a flux in copper smelting. Ground quartz is

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also used in filters and in tooth powders and by dentists as a detergent.

Sand and crystalline quartz have been used in making silicon and alloys of silicon with iron, copper, and other metals in the electric furnace. Quartz may be fused in the electric furnace to make chemical apparatus, such as tubes, crucibles, and dishes.

The material known commercially in the United States as tripoli, which is the siliceous residue of decomposed limestones, also yields an excellent grade of pulverized silica, which is used for the same purpose as silica powder obtained from massive crystalline quartz and from sands and sandstones. Diatomaceous (infusorial) earth is also used to make polishing powder that is employed for similar uses to those for which quartz, sand, and tripoli powders are employed, but diatomaceous earth has somewhat different properties and most of it finds different application, as insulating and filter material.

PRODUCTION.

The reports to the United States Geological Survey on the production in 1918 of silica for various uses considered in this chapter are summarized in the following table. The combined output of these materials decreased 73 per cent in quantity and 41 per cent in value in 1918, as compared with 1917.

Silica sold for pottery, paints, fillers, polishers, abrasives, and other uses in 1916, 1917, and 1918.

Material.	1916		1917		1918	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Quartz (vein quartz, pegmatite, and quartzite)	88,514	$242,786	142,673	$318,069	71,740	$259,330
Sand and sandstone [a]	110,603	489,863	532,454	1,195,142	98,956	620,584
Tripoli (ground and otherwise prepared)	43,257	215,216	26,069	338,188	19,982	199,854
Diatomaceous earth [b]	2,721	26,337	3,033	31,368	2,965	24,947
	245,095	974,202	704,229	1,882,767	193,643	1,104,715

[a] Includes only finely ground material. Figures probably incomplete.
[b] Excludes California product used for filters and as insulating and fireproofing material.

These figures clearly reflect the influence of war conditions on the silica industry. In only those uses, particularly for foundry mold wash and for grinding and polishing, of which the war required increased output, was there increased demand for silica. The consumption in pottery, paints, wood filler, and finishing abrasives for woodworking was largely curtailed either directly as nonessential or indirectly by demands on manufacturing plants for other lines of production.

SILICA INDUSTRY IN 1918, BY STATES.

Alabama.—Only a very small silica output in 1918 was reported from Trussville, Jefferson County, Ala. The production of silica refractories, cleansing, and abrasive materials in Calhoun and Jefferson counties has ceased.

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Arizona.—A small output of quartz for copper smelting was reported from Cochise County, Ariz.

California.—California in 1918 produced 3,544 short tons of quartz, valued at $4,489. The output was made by the Eldorado Lime & Mineral Co., of San Francisco, from quartz boulders collected at Ione, Amador County, and was used as flux and in the manufacture of silica brick; by Alva Joyner at Exeter, Tulare County, and used for porcelain; by Charles Biedleman at Blaine Ranch, Tulare County, and used for porcelain; by J. LaKamp from quartz boulders at Dutch Flat, Placer County, and used chiefly for foundry molds; by Thompson & LaBorde at Lakeview, Riverside County, and used for porcelain and glass. The following California firms have been reported as silica grinders: West Coast Porcelain Manufacturing Co., Millbrae; Pacific Porcelain Ware Co. and Pacific Sanitary Co., Richmond; Stockton Fire & Enamel Brick Co., Stockton; Judson Manufacturing Co., Emeryville.

Colorado.—The production of silica in Colorado in 1918 was reported by the Standard Fire Brick Co. from quartzite quarried at Carson City and Parkdale, Pueblo County, and by M. D. Funk, at Wray, where the output was used for manufacturing cleansing compounds. The production of quartz in Colorado for metallurgical flux has not been recorded.

Connecticut.—The output of quartz in Connecticut in 1918 came from Litchfield, Litchfield County; it was obtained by the Lithowhite Silex Co., and was ground at Still River, Conn., for use in soap, pottery, paint, and other manufactures. This company's Still River mill also ground quartz obtained at Cheshire, Mass.

The quarries on Lantern Hill, North Stonington, New London County, which were formerly a source of considerable silica, did not produce in 1918, but plans for a new grinding plant and future production were under consideration.

Connecticut produced also a little diatomaceous earth.

Illinois.—The sandstone quarries of La Salle and Ogle counties, Ill., produce large quantities of silica, most of which is reported in the sand and gravel chapter of Mineral Resources. The National Silica Co., at Oregon, Ogle County, and the Wedron Silica Co., at Wedron, La Salle County, ground in 1918 many thousands of tons which are included in the above table and which were used for pottery, paints, and foundry mold wash. Illinois sand and sandstone are also ground by silica mills in Wisconsin, Ohio, and Pennsylvania. The State also contributed heavily to the silica supplies of the country from the tripoli deposits in Alexander and Union counties. This output is reported in the abrasives chapter of Mineral Resources.

Maine.—Quartz was produced in Maine in 1918 from pegmatites, which were also worked for feldspar, by the Trenton Flint & Spar Co., at Cathance, Sagadahoc County, and by the Maine Feldspar Co., near Danville, Androscoggin County. The product was used for pottery and for the manufacture of ferrosilicon.

Maryland.—The quartz output in Maryland is derived from quartz veins and pegmatites. In 1918 the marketed product was 6,826 short tons of crude quartz, valued at $22,969, and 2,189 short tons of ground quartz, valued at $24,827. The active producers were S. P. Dunkel & Son, Baltimore, who worked a quartz vein near Florence in Howard County; the Guilford & Waltersville Granite

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Co., of Baltimore, which works pegmatite near Granite, Baltimore County; the Indian Rock Flint Co., which works quartz veins near and a mill at Conowingo, Harford County; the Maryland Quartz Co., of Baltimore, which grinds in a mill at Glen Morris, Baltimore County, vein quartz collected in that vicinity; Thomas & Son, of Westminster, who obtain quartz from veins and pegmatites in Carroll County near Marriottsville; H. Clay Whiteford & Co., of Flintville, who work a quartz vein and a mill near Flintville. The Maryland product is used largely for pottery, but also for wood filler, for abrasive soaps, for packing acid towers, and otherwise in the manufacture of chemicals and for filters.

Massachusetts.—The very large production of silica "sand" from the quartzite near Cheshire, Mass., is covered in the chapter on sand and gravel. A part of it, however, is used for abrasives, paints, fillers, and for other uses here considered. This part was produced by the Enos Adams Co., of Bennington, Vt., and the Cheshire White Quartz Sand Co. and the Lithowhite Silex Co., of Litchfield, Conn. The last-named company ground most of its Massachusetts product at Still River, Conn.

Michigan.—In Michigan there was one silica producer in 1918, as in previous years—the Michigan Quartz Silica Co., of Milwaukee, Wis. Vein quartz and quartzite are obtained in Ishpeming, Mich., and are ground at the company's plant in North Milwaukee. The product is used chiefly as a wood filler, also in paint, and to a small extent for other purposes.

Nevada.—A milling plant was reported in process of construction near Beatty, Nye County, Nev., where a pure quartzite is to be quarried and prepared for use in making glass, soap, fillers, paint, and enamel ware. The plant began operations January 3, 1919.

New Jersey.—A large output of sand from Camden County, N. J., was ground by the Pennsylvania Pulverizing Co., Williamstown Junction, for use in pottery, scouring soaps, and mold wash.

New York.—Quartz quarries at Bedford and Newcastle, Westchester County, N. Y., were operated by the Bedford Mining Co., Bedford, N. Y., in 1918. Most of the output was ground in Connecticut and used in making pottery, paint, wood filler, and soap.

North Carolina.—Quartz was quarried in 1918 by the Oliver Quartz Co., Charlotte, N. C., near Mount Holly in Gaston County, Wadeville in Montgomery County, and Norwood in Stanly County, and by Claud Hafer at Troy in Montgomery County. The output was used largely for packing acid towers; part was ground and otherwise prepared for use in the manufacture of acid-proof cements. A quantity of quartz for copper smelting was obtained in the vicinity of Murphy, Cherokee County.

Ohio.—No production of quartz was reported from Ohio in 1918, but large quantities were ground in the State and sold to local potteries and other manufactories.

Pennsylvania.—In 1918 quartz was marketed by two producers in Pennsylvania. The Columbia Flint Co. worked quarries in quartz veins near Bendersville and operated a mill at Aspers, Adams County, and H. T. A. Rhodewalt worked a quartz vein near Cornog, Chester County. In addition to this output of vein quartz the Pennsylvania Pulverizing Co., Lewistown, Pa., made a large output of ground silica derived from sandstones quarried and ground at Granville

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and Dawson Mills, Mifflin County. The combined silica production of Pennsylvania in 1918 was 39,554 short tons, valued at $257,463, and was used for pottery, enamel ware, mold wash, sandpaper, and abrasive soaps.

Tennessee.—In 1918 Tennessee produced a large quantity of quartz, but the material was of comparatively low grade and of small value. It was used by the Tennessee Copper Co. and the Ducktown Sulphur, Copper & Iron Co. as flux in copper smelting.

Virginia.—Material (said to be vein quartz) obtained at Mendota, Washington County, Va., in 1918 was marketed for use in polishing and cleansing compounds in Bristol, Tenn.

West Virginia.—Two producers in West Virginia—the National Silica Works, at Berkeley Springs, and the Pennsylvania Pulverizing Co., at Hancock station, Morgan County—ground sand and sandstone for use in the manufacture of pottery, scouring soaps, paints, and for mold wash.

Wisconsin.—The Wausaw Quartz Co., operating at Flieth, Marathon County, Wis., produced quartz in 1918. The product is derived from a very pure quartzite and is used for filter beds, for roofing, for concrete work, for chicken grits, and for sandpaper. The Michigan Quartz Silica Co. operated a silica mill at North Milwaukee, grinding material obtained in Michigan and elsewhere.

FLINT OR CHERT.

PRODUCTION.

So far as can be learned no true flint or chert has been produced for consumption as crushed or ground silica in grinding mills in the United States. The manufacture of flint, chert, and quartzite blocks for tube mill lining is reported in the chapter on abrasive materials.

IMPORTS.

The Department of Commerce records imports of "flint, flints, and flint stones, unground," from several countries. These imports are partly flint pebbles for use in grinding mills and partly material for such uses as are listed in this report. The accurate separation or classification of these materials is impossible. The imports of flint "for consumption" into the United States in 1918 were valued at $135,636, compared with $197,156 in 1917, $313,120 in 1916, $274,904 in 1915, $432,694 in 1914, and $324,662 in 1913. A detailed table of imports of flint pebbles of various kinds, by countries, and a discussion of domestic substitutes for foreign flint pebbles are given in the chapter on abrasives in Mineral Resources for 1917.

QUARTZ.

PRODUCTION.

Quartz from quartz veins, pegmatite, and quartzite, amounting to 1,740 short tons and valued at $259,330, was sold in 1918. This was a decrease in quantity of 50 per cent and in value of 18 per cent, as compared with 1917. There was marked decrease in sales of both crude or crushed and ground quartz, and the combined sales of both were less in quantity than has been reported in any year since 1910.

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This falling off was due not only to curtailment of the consuming industries by the war, but also to the growing tendency to replace quartz from these sources by sand and sandstone. The quartz (or silica) here considered was produced in Alabama, Arizona, California, Colorado, Connecticut, Maine, Maryland, Massachusetts, Michigan, New York, North Carolina, Pennsylvania, Tennessee, and Wisconsin.

Prices of crude and crushed quartz ranged from $1 to $7.50 a short ton, and, exclusive of large quantities nominally valued at $1 and used in copper smelting, averaged about $3.47 a ton, as compared with $3.25 in 1917, $2.37 in 1916, and $3.30 in 1915. Prices for finely ground, pure quartz commonly ranged from $9 to $18.50 a ton, with exceptional lots selling as high as $40. The average price computed on total sales was $12.80, as compared with $12.25 in 1917, $9.09 in 1916, and $10.56 in 1915.

Quartz sold in the United States, 1910–1918.

Year.	Crude.		Ground.		Total.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
1910	49,886	$80,984	13,691	$112,773	63,577	$193,757
1911	77,759	70,430	10,184	84,692	87,943	155,122
1912	82,205	67,256	15,669	124,429	97,874	191,685
1913	74,176	54,442	23,726	147,046	97,902	201,488
1914	123,508	88,820	29,893	271,682	153,401	360,502
1915	94,299	80,630	18,276	192,923	112,575	273,553
1916	70,417	78,283	18,097	164,503	88,514	242,786
1917	126,575	120,856	16,098	197,213	142,673	318,069
1918	61,008	121,888	10,732	137,442	71,740	259,330

Vein and pegmatite quartz and quartzite sold in the United States, 1917–18, by States.

State.	Crude.		Ground.		Total.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
1917.						
California, Michigan, and Wisconsin	7,065	$14,914	7,018	$63,134	14,083	$78,048
Maine, Massachusetts, New York, and Pennsylvania	115,193	90,140	5,286	94,248	120,479	184,388
Maryland and North Carolina	4,317	15,802	3,794	39,831	8,111	55,633
	126,575	120,856	16,098	197,213	142,673	318,069
1918.						
Arizona, California, Colorado, Michigan, and Wisconsin	8,088	37,211	1,269	17,212	9,357	54,423
Connecticut, Maine, Massachusetts, New York, and Pennsylvania	6,686	16,045	7,274	95,403	13,960	111,448
Alabama, Maryland, North Carolina, and Tennessee	46,234	68,632	2,189	24,827	48,423	93,459
	61,008	121,888	10,732	137,442	71,740	259,330

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POTASH.

By W. B. Hicks.

INTRODUCTION.

Only potash materials derived from original sources such as alunite, brine, and kelp have heretofore been included under domestic production in the annual reports on potash. Such materials vary greatly in composition and content of potash, and are used as fertilizers or as raw materials in the production of potassium compounds. They include among other materials more or less refined potassium sulphate derived largely from alunite, potassium chloride, and crude mixed salts derived largely from brines and kelp, and crude potassium carbonate derived from wood ashes. Their value depends essentially on the percentage of actual potash (K_2O) present in soluble form in the materials as marketed.

Refined potassium salts, which constitute a large part of the subject matter of the present report, may be obtained from original sources—for example, potassium sulphate from alunite—but most of them are manufactured from other potassium salts used as raw materials either imported or of domestic origin. They are used largely in chemical industries. Their inherent value often depends on the properties of the acid radicles with which the potassium is combined rather than on the properties of potassium. For example, it is primarily the oxidizing power of the nitrate and chlorate radicles and not the properties of the potassium that determines the use of potassium nitrate and potassium chlorate in explosives. Therefore, it is not surprising that the more economical sodium salts are gradually replacing potassium salts in chemical industries. At the same time slight differences in properties give certain potassium salts a superiority over the corresponding sodium salts and make them preferred in many applications and absolutely necessary in others. For instance, potassium chlorate, permanganate, and bichromate crystallize well and are easily purified, but the reverse is true of the corresponding sodium salts. Furthermore, the hygroscopic nature of sodium nitrate and of sodium chlorate preclude their use in explosives and matches, except under very special conditions.

The statistical data relating to the domestic production of refined potassium salts in 1918 have been compiled from reports submitted by producers and elicited through correspondence. Inquiries were sent to all firms thought to be interested in the production of potassium salts; practically all of them responded and most of them coop-

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erated generously in giving the information requested. Although some producers may not have been reached, the compilation is believed to be practically complete.

DOMESTIC PRODUCTION.

POTASH MATERIALS DERIVED FROM ORIGINAL SOURCES.

The potash-bearing materials reported to the United States Geological Survey as produced in the United States in 1918 amounted to 207,686 short tons, having an approximate average content of potash (K_2O) of 26.4 per cent. This was equivalent to a total content of 54,803 short tons of potash (K_2O). Actual sales amounted to 38,580 short tons, valued at $15,839,618, or $4.11 per unit of potash. The production in 1917 was 126,961 short tons of potash-bearing materials, having an average content of 25.6 per cent of K_2O, or a total content of potash of 32,573 short tons, valued at $13,980,577, or $4.29 per unit of potash. The production in 1918 was, therefore, nearly 70 per cent more than in 1917, and it represented about 22 per cent of the normal consumption in the country, which is estimated to be about 250,000 short tons of potash annually. The following table shows the increase in the domestic production of potash during the last few years and gives some idea of the growth of the industry:

Potash produced and sold in the United States, 1915–1918.

Year.	Number of producers.		Production.		Sales. [a]		
	Total.	Exclusive of producers of wood-ash potash.	Crude potash (short tons).	Available content of potash (K_2O) (short tons).	Crude potash (short tons).	Available content of potash (K_2O) (short tons).	Value f. o. b. plant.
1915	[b] 5	5	4,374	1,090	4,374	1,090	$342,000
1916	70	25	35,739	9,720	35,739	9,720	4,212,730
1917	95	46	126,961	32,573	126,961	32,573	13,980,577
1918	123	77	207,686	54,803	140,343	38,580	15,839,618

[a] Production and sales were practically the same from 1915 to 1917, and no distinction was made between them.

[b] Although no production was reported from wood ashes it is probable that an appreciable quantity of potash was produced from that source in 1915.

In 1918 the production came from 10 distinct classes of raw materials. Natural brines furnished about 73 per cent of the output, the Nebraska lakes alone contributing about 53 per cent and Searles Lake, Calif., the second largest quantity from a single source. Kelp yielded about 9 per cent of the total production, followed by smaller contributions from molasses, alunite, cement, etc. The figures of production for 1918, classified according to sources, are shown in the following table.

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Potash produced and sold in the United States in 1918, classified according to sources.

Source.	Number of producers.	Production.			Sales.		
		Crude potash (short tons).	Available content of potash (K_2O).		Crude potash (short tons).	Available content of potash (short tons).	Value f. o. b. plant.
			Quantity (short tons).	Percentage of total.			
Mineral:							
Natural brines—							
Nebraska lakes	19	116,662	28,854	53	57,522	14,011	$5,098,023
Other sources	8	32,390	10,862	20	30,849	10,319	4,184,449
Alunite	4	6,180	2,621	5	6,180	2,621	1,276,774
Dust from cement mills	12	12,652	1,549	3	11,172	1,366	539,567
Dust from blast furnaces	6	3,155	310	.5	3,155	310	152,571
Silicate rocks							
Organic:							
Kelp	8	14,029	4,804	9	14,029	4,804	2,296,963
Molasses, distillery waste	8	11,792	3,467	6	11,792	3,467	1,335,516
Steffens water from beet-sugar refineries	8	8,795	1,374	2	3,650	742	267,309
Wood ashes	51	1,100	673	1	1,063	651	549,745
Wool washings and miscellaneous	4	931	289	.5	931	289	138,688
	123	207,686	54,803	100	140,343	38,580	15,839,618

Potash materials marketed in 1918 varied greatly in composition and in content of potash. Crude mixed salts, containing 20 to 28 per cent of potash (K_2O) and composed largely of carbonates and sulphates of sodium and potassium, constituted about 58 per cent of the output; muriate, containing 60 to 96 per cent of potassium chloride, equivalent to 38 to 62 per cent of potash, about 24 per cent; sulphate, containing 35 to 51 per cent of potash, 6 per cent; and low-grade chloride, crude carbonate, caustic, potash char and ash, cement and blast-furnace dust, and miscellaneous the remainder. Most of the muriate[1] was of low grade and much of it contained borax, while the larger portion of the sulphate was of high grade. Crude carbonate and caustic was largely the product made from wood ashes. As marketed, much of the carbonate contained about 70 per cent of potassium carbonate mixed with about 30 per cent of potassium sulphate and other impurities. Considerable quantities were converted into caustic, which contained between 80 and 90 per cent of potassium hydroxide, equivalent to about 70 to 75 per cent of potash (K_2O). Potash char and ash came from kelp, molasses distillery waste, and Steffens waste water, and contained 24 to 44 per cent of potash in the form of mixed salts along with considerable quantities of insoluble matter. The products classified as miscellaneous include ground kelp, residues from molasses distillery waste, concentrated Steffens waste water from beet-sugar refineries, alum, calcined alunite, and vegetable ash.

[1] See also regarding muriate, p. 427; sulphate, p. 436; crude carbonate, 424; and caustic, p. 430.

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Potash produced in the United States in 1918, classified according to product marketed.

Potash material.	Crude potash (short tons).	Available content of potash (K_2O).		
		Percentage.	Quantity (short tons).	Percentage of total.
Crude mixed salts	124,467	20–38	31,793	58
Muriate	31,486	38–62	13,184	24
Sulphate	6,897	35–51	3,294	6
Low-grade chloride	6,589	10–25	901	2
Crude carbonate	914	40–70	533	1
Caustic [a]	262	40–80	172	
Potash char and ash	6,875	24–44	2,203	4
Dust from cement and blast furnaces	13,557	2–9	938	2
Miscellaneous [b]	16,639	4–20	1,795	3
	207,686	2–70	54,803	100

[a] The larger portion of the caustic contained about 75 per cent of K_2O. About one-fourth of it was sold in solution which contained from 40 to 45 per cent of K_2O. See page 430.

[b] Includes ground kelp, low-grade materials from molasses distilleries and beet-sugar refineries, alum, calcined alunite, and plant ashes.

Approximately 53 per cent of the total production came from Nebraska, 34 per cent from California, 7 per cent from Utah, and the other 6 per cent from 18 other States and Porto Rico. About 95 per cent came from Western States and was handicapped by freight rates of about 50 cents per unit of potash (K_2O) to the eastern markets. The production classified according to States is shown in the following table:

Potash produced in the United States in 1918, classified according to States.

State.	Number of plants.	Crude potash (short tons).	Available content of potash (K_2O).	
			Quantity (short tons).	Percentage of total.
Nebraska	19	116,662	28,854	53
California	21	55,801	18,824	34
Utah	8	11,783	3,878	7
Alabama	1			
Louisiana	3	11,664	1,237	2
Maryland	1			
Tennessee	1			
Colorado	2			
Montana	1	1,120	320	1
Nevada	1			
Washington	1			
Ohio	3			
Indiana	2	1,362	153	
Iowa	1			
Missouri	1			
Michigan	26	1,564	404	1
Wisconsin	22	618	398	1
Pennsylvania	7	5,405	377	
New York	2	1,179	86	1
Porto Rico	1			
Maine	2	528	272	
Massachusetts	2			
	128	207,686	54,803	100

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STOCKS.

Nearly 70,000 short tons of crude potash containing more than 16,000 tons of potash (K_2O) was reported as produced during 1918 in excess of sales and held by producers at the end of the year, as appears from the following table:

Potash held by producers in the United States at the end of 1918.

Sources.	Stocks.	
	Crude potash (short tons).	Available content of potash (K_2O) (short tons).
Salines:		
Nebraska lakes	59,140	14,843
Other sources	1,541	543
Cement dust	1,480	183
Steffens waste water	5,145	632
Wood ashes	37	22
	67,343	16,223

REFINED POTASSIUM SALTS.

The domestic production of refined potassium salts in 1918, exclusive of chlorides and sulphates, as reported to the United States Geological Survey, amounted to 53,661,676 pounds, and the sales amounted to 43,833,503 pounds, valued at $16,032,880. Forty-seven firms reported production, and it is probable that a few firms failed to make returns. The figures are classified in the following table with as much detail as is consistent with the confidential nature of the individual reports submitted.

Refined potassium salts produced and sold in the United States in 1918.[a]

Potassium salt.	Number of firms.	Production (pounds).	Sales.	
			Quantity (pounds).	Value.
Acetate	5	93,307	90,229	$59,314
Aluminum sulphate (alum)[b]	3	10,922,955	9,699,645	251,181
Bromate, iodate, and perchlorate	3	513,100	510,099	243,198
Bromide	3	666,119	616,232	551,079
Carbonate and bicarbonate[c]	4	229,287	201,574	104,432
Chlorate	3	9,753,424	9,753,424	2,837,892
Chromate and bichromate	4	681,346	1,003,598	407,703
Citrate	6	99,193	96,273	141,517
Ferrocyanide	3	457,267	306,535	204,190
Hydroxide (caustic)	14	1,984,847	1,594,580	856,148
Iodide	8	521,678	481,301	1,587,656
Nitrate	4	16,250,433	8,176,382	2,206,788
Permanganate	9	562,416	530,337	922,746
Tartrates[d]	5	10,869,874	10,717,674	5,596,732
All others[e]	3	56,430	54,520	62,214
	.....	53,661,676	43,833,503	16,032,880

[a] For the production of potassium chloride, potassium sulphate, and other products derived from original sources see page 388.
[b] Includes both the hydrous (potash alum) and the anhydrous (burnt alum) salt.
[c] In addition, 1,827,000 pounds of crude carbonate from wood ashes was produced, and 1,753,000 pounds, valued at $331,000, was sold. See page 424.
[d] Includes neutralacid (cream of tartar), sodium (Rochelle salt), and antimony, (tartar emetic) tartrates.
[e] Includes bisulphate, bisulphite, ferricyanide, oxalate, phosphate, sulphide, and sulphite.

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The following table summarizes the available data on the production of refined potassium salts in 1914. Figures for 1915, 1916, and 1917 have not been compiled.

Refined potassium salts produced in the United States in 1914.[a]

Salt.	Number of producers.	Quantity (pounds).	Value.
Potassium aluminum sulphate:			
Potash alum	5	12,765,000	$219,968
Burnt alum	4	22,629,000	364,656
Potassium carbonate[b]	.....	.....	49,651
Potassium ferrocyanide	.....	3,204,684	451,092
Potassium nitrate	.....	29,490,000	1,244,051
Potassium bitartrate (cream of tartar)	8	12,646,120	3,124,958
All others[c]	[d] 42	.....	2,801,225
	.....	80,724,804	8,255,601

[a] Chemical and allied industries: U. S. Dept. of Commerce Bur. Census, census of manufactures, 1914.
[b] Includes crude, unrefined, and refined carbonate.
[c] Includes potassium acetate, bicarbonate, chlorate, citrate, hydroxide, iodate, and silicate.
[d] Includes 17 wood-ash potash producers and producers of nitrate, carbonate, and items listed under "All others."

IMPORTS.

In contrast to the large quantity and low cost of German potash used in the United States before the war, the imports in 1918 amounted to only 7,957 short tons of potash (K_2O), valued at $8,907,836, or $1.12 per unit of potash (20 pounds of K_2O), as rated in import returns. Imports from 1913 to 1918 are classified according to materials imported in the following table:

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Potash materials imported and entered for consumption in the United States, 1913–1918.[a]

Material.	Approximate potash (K_2O) content (per cent).	1913				1914				1915			
		Quantity (short tons).	Available content of potash (K_2O).		Value.	Quantity (short tons).	Available content of potash (K_2O).		Value.	Quantity (short tons).	Available content of potash (K_2O).		Value.
			Quantity (short tons).	Percentage of total.			Quantity (short tons).	Percentage of total.			Quantity (short tons).	Percentage of total.	
Kainite	12.4	521,176	64,626	23.9	$2,201,730	351,566	43,594	21.0	$1,551,115	7,475	927	1.9	395,440
Manure salts	20.0	250,529	50,106	18.5	2,245,509	189,245	37,849	18.3	1,846,475	15,408	3,081	6.3	200,584
Muriate	50.0	237,630	118,815	43.8	7,075,745	185,761	92,881	44.9	5,745,385	64,670	32,335	66.2	2,296,606
Sulphate	48.6	44,349	21,554	8	1,677,429	40,224	19,554	9.4	1,557,224	12,708	6,176	12.6	664,484
Total[b]		1,053,684	255,101	94.2	13,200,413	766,796	193,878	93.6	10,700,199	100,256	42,519	87.0	3,257,114
Bicarbonate	46.0	223	103	.....	20,968	169	78	.....	16,080	132	61	.1	14,456
Bitartrate (argol)	20.0	14,499	2,900	1.1	2,779,180	13,664	2,733	1.4	3,016,073	8,339	1,668	3.4	2,132,276
Bitartrate (cream of tartar)	25.0	75	19	.....	28,314	590	148	.1	234,657	123	31	.1	60,869
Carbonate, crude	61.0	4,858	2,963	1.1	272,973	4,663	2,844	1.4	265,158	2,698	1,643	3.4	191,621
Carbonate, crude black salts	50.0	344	172	.1	17,852	1,284	642	.3	44,086	2,074	1,037	2.1	98,409
Carbonate, refined	67.0	6,145	4,117	1.5	393,284	3,371	2,259	1.1	224,384	622	417	.9	60,491
Caustic	80.0	4,324	3,459	1.3	342,056	3,642	2,914	1.4	285,739	1,016	813	1.7	100,035
Chlorate	38.0	596	226	.1	64,468	13	5	.....	2,235	8	3	.....	3,666
Chromate and bichromate	40.0	9	4	.....	1,819	15	6	.....	2,375	16	6	.....	2,902
Cyanide	70.0	735	514	.2	216,844	209	146	.1	59,278	436	305	.6	134,123
Ferricyanide (red prussiate)	42.0	34	14	.....	12,035	40	17	.....	14,446	26	11	.....	9,044
Ferrocyanide (yellow prussiate)	44.0	1,706	751	.3	388,379	1,522	670	.3	334,592	558	246	.5	124,382
Iodide	28.0	.....	.....	.....	.....	[c]270	[c]76	.....	491	[c]4	[c]1	.....	13
Nitrate (saltpeter), crude	40.0	4,826	193	.1	261,078	1,115	446	.2	74,869	3	1	.....	400
Nitrate (saltpeter), refined	46.0	203	93	.....	22,602	135	62	.....	15,062	.....	.....	.....	.....
Permanganate	29.0	273	79	.....	38,188	746	216	.1	102,619	315	91	.2	64,592
Rochelle salt	22.0	54	12	.....	13,412	113	25	.....	29,318	69	15	.....	3,955
Total[d]		38,904	15,619	5.8	4,873,452	31,291	13,211	6.4	4,721,412	16,430	6,348	13.0	3,001,234
Grand total		1,092,588	270,720	100.0	18,073,865	798,087	207,089	100.0	15,421,611	116,686	48,867	100.0	6,258,348

[a] The figures in this table were compiled from the records of the Bureau of Foreign and Domestic Commerce, United States Department of Commerce, by recalculation to short tons and to actual potash (K_2O) and by giving the totals for calendar years instead of fiscal years. The tons are calculated to the nearest even unit and the values are those given in the original records, so that the value given for a high-priced commodity received in small quantity may not be strictly applicable to the quantity given. For instance, 2,705 pounds of cyanide received in 1916 is reported as 1 ton, but the value given is that of the actual quantity received. Furthermore the values are those placed on the commodities by the shippers, and represent the values at point of shipment and do not agree with market quotations in this country.

[b] Used principally in fertilizers.

[c] Pounds.

[d] Used principally in chemical industries.

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Potash materials imported and entered for consumption in the United States, 1913–1918—Continued.

Material.	1916				1917				1918			
	Quantity (short tons).	Available content of potash (K_2O).		Value.	Quantity (short tons).	Available content of potash (K_2O).		Value.	Quantity (short tons).	Available content of potash (K_2O).		Value.
		Quantity (short tons).	Percentage of total.			Quantity (short tons).	Percentage of total.			Quantity (short tons).	Percentage of total.	
Kainite	40	5	0.1	$1,173								
Manure salts	1,241	248	3.1	21,273	252	50	0.6	$9,047				
Muriate	1,299	650	8.3	348,961	683	342	4.2	158,410	424	212	2.7	$102,109
Sulphate	1,693	823	10.4	81,684	230	112	1.4	21,702	101	49	.6	15,329
Total [a]	4,273	1,726	21.9	453,091	1,165	504	6.2	189,159	525	261	3.3	117,438
Bicarbonate	2	1	.....	1,133	76	35	.4	71,975	36	17	.2	34,279
Bitartrate (argol)	14,943	2,989	37.9	5,021,291	14,277	2,855	35.2	4,740,912	14,041	2,808	35.3	4,782,267
Bitartrate (cream of tartar)	48	12	.2	29,213	48	12	.2	25,434	7	2	.....	3,355
Carbonate (crude)	341	208	2.6	113,413	2,967	1,810	22.4	1,042,689	4,297	2,621	32.9	2,273,202
Carbonate, crude black salts	1,081	541	6.9	109,121	908	452	5.6	220,408	228	114	1.5	47,956
Carbonate, refined	76	51	.7	40,496	222	140	1.9	121,111	104	70	.9	65,974
Caustic	24	19	.2	16,694	35	28	.4	29,308	.....	.....	.....	.....
Chlorate	5	2	.....	7,167	508	191	2.4	404,783	355	135	1.7	248,160
Chromate and bichromate	[b] 459	[b] 184	.....	75	1	[b] 800	.....	962	[b] 20	[b] 8	.....	8
Cyanide	1	1	.....	803	35	25	.3	49,606	12	8	.1	10,278
Ferricyanide (red prussiate)	2	1	.....	6,952	5	2	.....	18,262	8	3	.....	29,201
Ferrocyanide (yellow prussiate)	25	11	.1	45,497	39	17	.2	57,897	65	29	.4	112,729
Iodide	5	1	.....	26,578	15	4	.....	66,823	32	9	.1	142,324
Nitrate (saltpeter), crude	5,769	2,308	29.3	1,519,375	4,606	1,842	22.7	660,044	4,672	1,869	23.5	906,549
Nitrate (saltpeter), refined	2	1	.....	771	368	169	2.1	50,606	2	1	.....	730
Permanganate	45	13	.2	33,728	5	1	.....	21,462	27	8	.1	128,438
Rochelle salt	.....	.....	.....	.....	17	4	.....	8,018	8	2	.....	4,948
Total [c]	22,369	6,159	78.1	6,972,307	24,122	7,596	93.8	7,599,247	23,894	7,696	96.7	8,790,398
Grand total	26,642	7,885	100.0	7,425,398	25,287	8,100	100.0	7,788,406	24,419	7,957	100.0	8,907,836

[a] Used principally in fertilizers. [b] Pounds. [c] Used principally in chemical industries.

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The first four salts listed in the foregoing table—kainite, manure salts, muriate and sulphate—are used principally in fertilizers. In 1913 they constituted about 94 per cent of the total potash imports, but in 1918 only 3.3 per cent. Kainite, the lowest-grade material imported, is a double sulphate and chloride of potassium and magnesium ($KCl.MgSO_4.3H_2O$) and theoretically contains 18.9 per cent of potash (K_2O). The product shipped is mixed with much sodium chloride and is sold with a guaranty of a minimum potash content of 12.4 per cent. It is sold as it comes from the mine without previous treatment for use in fertilizers. In 1913 nearly 24 per cent of the total potash imports came as kainite. Manure salts are essentially mixtures of potassium chloride, sodium chloride, and magnesium sulphate and are low-grade fertilizer materials. Several grades are produced which contain from 20 to 30 per cent of potash (K_2O). Nearly all material of this class, however, comes to the United States as the 20 per cent grade, and the small quantities of other grades imported are included in the table under manure salts. Before the war manure salts constituted about 18 per cent of the potash imported. In 1918 no kainite and no manure salts were imported. Muriate is a high-grade fertilizer material containing about 80 per cent of potassium chloride and 20 per cent of sodium chloride. In 1913 it constituted about 44 per cent of the total potash imported and in 1918 only 0.6 per cent. Although used largely in fertilizers, it is a raw material in the manufacture of many potassium compounds, notably caustic, carbonate, chlorate, perchlorate, and nitrate. Sulphate as usually imported contains about 90 per cent of potassium sulphate. It is used principally in fertilizers, especially for growing tobacco, but considerable quantities of it are used in chemical industries. In 1913 21,594 metric tons of muriate, equivalent to 10,905 metric tons of K_2O, and 643 metric tons of potassium sulphate, containing 313 metric tons of K_2O, were imported for chemical purposes.[1]

The other materials listed in the table of imports are manufactured potassium salts, more or less refined, and are used in chemical industries. In 1913 they made up about 6 per cent of the potash imports, and in 1918 96.7 per cent. Most of them are also manufactured in the United States and are described on pages 420–439. Imports in 1918 are classified in the following table as refined salts and crude salts:

[1] Federal Trade Commission report on fertilizer industry, 1916, p. 115.

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Potassium salts imported and entered for consumption in the United States in 1918.

Potassium salts.	Quantity (short tons).	Value.
Refined salts:		
Bicarbonate	36	$34,279
Bitartrate	7	3,355
Carbonate	104	65,974
Chlorate	355	248,160
Chromate and bichromate	a 20	8
Cyanide	12	10,278
Ferricyanide	8	29,201
Ferrocyanide	65	112,720
Iodide	32	142,324
Nitrate	2	730
Permanganate	27	128,438
Rochelle salt	8	4,948
	656	780,424
Crude salts:		
Muriate	424	102,109
Sulphate	101	15,329
Bitartrate (argol)	14,041	4,782,267
Carbonate	4,297	2,273,202
Carbonate, black salts	228	47,956
Nitrate	4,672	906,549
	23,763	8,127,412
Grand total	24,419	8,907,836

a Pounds.

For many years practically all the potash imported came from Germany. During the war imports from various parts of the world represented both accumulated stocks and domestic production in those countries. In 1917 approximately 17 per cent of the imports came from Russia, 15 per cent from England, 14 per cent from Japan, 12 per cent from Chile, 11 per cent from Spain, 10 per cent from Italy, 9 per cent from France, 5 per cent from Portugal, 4 per cent from Argentina, and the remaining 3 per cent from other countries. About 35.5 per cent of the total came in the form of argol, cream of tartar, and Rochelle salt, which had previously not been included in the statistics of potash. Approximately 28 per cent of these commodities came from Italy, 26 per cent from France, 15 per cent from Spain, 12 per cent from Portugal, 10 per cent from Argentina, and the remaining 9 per cent from other countries.

In 1918 20.9 per cent of the potash imported came from Russia, 19.6 per cent from India, 12.4 per cent from Japan, 12.2 per cent from Italy, 11.4 per cent from Spain, and 23.5 per cent from 15 other countries. The imports in 1918 from various countries are shown in the following table:

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Potash materials imported by the United States in 1918 in short tons.[a]

Country.	Muriate.		Sulphate.		Bitartrate (argol).		Carbonate.		Cyanide.		Nitrate.		All others.		Total quantity.		Percentage of total.
	Quantity.	Content of potash (K_2O). (50 per cent.)	Quantity.	Content of potash (K_2O). (48.6 per cent.)	Quantity.	Content of potash (K_2O). (20 per cent.)	Quantity.	Content of potash (K_2O). (61 per cent.)	Quantity.	Content of potash (K_2O). (70 per cent.)	Quantity.	Content of potash (K_2O). (40 per cent.)	Quantity.	Content of potash (K_2O). (50 per cent.)	Quantity.	Content of potash (K_2O).	
Russia in Europe							2,719	1,659							2,719	1,659	20.9
British India							636	388			2,915	1,166			3,551	1,554	19.6
Japan	411	206	99	48			913	557					343	172	1,766	983	12.4
Italy					4,858	972									4,858	972	12.2
Spain					3,585	717	228	139	65	46					3,878	902	11.4
France					2,561	512									2,561	512	6.4
England					[b] 216	[b] 43			6	4	963	385	5	2	974	391	4.9
Portugal					1,916	383									1,916	383	4.8
British East Indies											710	284			710	284	3.6
Argentina					573	115									573	115	1.5
Dutch East Indies	13	6					76	46							89	52	.7
French Africa					254	51									254	51	.6
Mexico							[b] 60	[b] 37			84	34	[b] 10	[b] 5	84	34	.4
Canada					7	1	27	17	[b] 50	[b] 35			1	1	35	19	.2
Chile					75	15									75	15	.2
China							25	15							25	15	.2
Greece					11	2									11	2	.....
Hongkong							4	2							4	2	.....
British South Africa					4	1									4	1	.....
Peru			2	1											2	1	.....
	424	212	101	49	13,844	2,769	4,628	2,823	71	50	4,672	1,869	349	175	24,089	7,947	100.0

[a] The figures in this table were compiled from the records of the Bureau of Foreign and Domestic Commerce, United States Department of Commerce, by recalculation to short tons and to actual potash (K_2O) and by giving the totals by the calendar year instead of the fiscal year. The tons are calculated to the nearest even unit. The data represent general imports and include imports both for immediate consumption and those going to warehouses, which may or may not be entered for consumption during the year. They differ slightly from the figures in the preceding table of imports, which represent imports for consumption.

[b] Pounds.

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Imports of the more important potassium salts for the years 1913 to 1918 are shown in the table on pages 391–392, which includes all the potassium salts listed in the records of the Bureau of Foreign and Domestic Commerce. Small quantities of other potassium salts imported are grouped with other commodities in customhouse office reports, so that data as to their quantity and value are not generally available. In a recent report, however, these data for the fiscal year ending June 30, 1914, have been made available and are shown in the following table:

Potassium salts imported and entered for consumption in the United States for the fiscal year ending June 30, 1914.[a]

Potassium compound.	Quantity (pounds).	Value.
Potassium (metal)	998	$330
Potassium acetate	528	108
Potassium aluminium sulphate (potash alum)	270,114	3,493
Potassium bicarbonate	478,903	22,783
Potassium bichromate	30,068	2,362
Potassium binoxalate	55,732	4,033
Potassium bisulphite (liquid, 30 per cent)	35,200	656
Potassium bisulphite (pure crystals)	185	16
Potassium bitartrate (pure crystals)	150,460	28,821
Potassium bromide	361	200
Potassium carbonate (crude black salts)	2,599,935	52,494
Potassium carbonate (crude)	9,042,754	239,691
Potassium carbonate (refined)	10,420,673	368,324
Potassium carbonate (chemically pure)	385	113
Potassium chlorate	40,480	3,503
Potassium chloride (pure white)	1,734,835	25,444
Potassium chloride (chemically pure)	25,015	1,115
Potassium chromate	4,205	460
Potassium chromium sulphate (chrome alum)	842,200	31,384
Potassium cyanide	808,721	113,199
Potassium ferricyanide (red prussiate)	90,007	15,350
Potassium ferrocyanide (yellow prussiate)	3,508,229	390,056
Potassium glycerophosphate	244	228
Potassium hydroxide (not in sticks)	8,395,049	320,753
Potassium hydroxide (refined, in sticks)	56,353	5,913
Potassium hypophosphite	300	130
Potassium iodate	62	153
Potassium iodide	169	491
Potassium iodometabisulphite	4,400	215
Potassium mercuric iodide	42	333
Potassium metabisulphite (liquid, 30 per cent)	120,147	6,070
Potassium metabisulphite (pure crystals)	3,620	488
Potassium metasulphite (commercial liquid)	9,521	574
Potassium metasulphite (pure)	224	37
Potassium nitrate (crude saltpeter)	3,546,580	115,344
Potassium nitrate (refined saltpeter)	367,640	20,368
Potassium nitrite (commercial)	109	20
Potassium nitrite (pure sticks)	305	104
Potassium oxalate (pure crystals)	107,060	9,108
Potassium oxalate (chemically pure)	289	64
Potassium perchlorate (purified crystals)	24,391	1,925
Potassium perchlorate (chemically pure)	64	18
Potassium permanganate	1,351,941	91,185
Potassium persulphate	236	920
Potassium phosphate (monobasic)	14	9
Potassium phosphate (dibasic)	4,179	990
Potassium phosphate (tribasic)	458	164
Potassium silicate (pure solution)	152,329	2,563
Potassium silicate (pure exsiccated)	231	43
Potassium sulphite (commercial liquid)	7,626	404
Potassium sulphite (commercial powder)	11,252	1,833
Potassium sulphite (pure powder)	750	351
Potassium sulphocyanide	9,035	1,578
Potassium titanium oxalate	77,238	10,146
	44,391,866	1,896,457

[a] Pickrell, E. R., Chemicals and allied products used in the United States: U. S. Dept. Commerce, Bur. Foreign and Domestic Commerce, Misc. Ser. 83, 1919. The table includes salts imported primarily for chemical purposes. For other imports see pages 391–392.

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In addition to the potassium salts listed in the preceding table and on pages 391–392, the following potassium salts were imported in 1914 in quantities valued at less than $100:

Potassium acridin, aluminate, ammonium chromate, potassium and iron tartrate, antimonate, antimony nitrate, arsenate, arsenite, benzene sulphonate, benzoate, benzo sulphoacid, benzol disulphonate, bifluoride, biiodate, biphosphate, bisulphate, borfluoride, bromate, butyrate, butylsulphate, cacodylate, chlorate of potassium and cocaine, chlorate of potassium and cocaine pastilles, chlorate and cocaine and soda borate, chloride and borax, citrate, cobalt cyanide, copper chloride, copper cyanide, cyanate, cyanide sodium, ethyl, ethyl sulphate, ethyl sulphonate, ferri oxalate, fluoreseinate, fluoride (purified), formate, gold chloride, hydrogen sulphate, hydrogen sulphide, hypophosphite, iodide strong paper, iodite, iron citrate, iron oxalate, iron sulphate, lactate, magnesium chloride, magnesium sulphate, methylsulphate, monosulphide, myronate, nitrite (pure crystals), nitro bisulphate, nitro prusside, oleate, percarbonate, periodate, phenate, phenolsulfonate para, phthalamide, pyroantimonate, pyrogallate solution, pyrophosphate, pyrosulphate, saccharate, salicylate, silicofluoride, sodium, sodium chloride, sodium sulphate, sodium urate, stannate, sulphide, telluride, tellurite, thiocyanate, tungstate purified, xanthogenate, zinc chloride.

EXPORTS.

A comparatively small quantity of potash is exported by the United States, and the statistics are far from complete. The available data are summarized in the following table:

Potassium salts exported from the United States, 1914, 1917, and 1918.

Potassium salt.	1914[a]		1917[b]		1918	
	Quantity (short tons).[c]	Value.	Quantity (short tons).[c]	Value.	Quantity (short tons).[c]	Value.
Muriate	.....	$89,886	.....	(d)	.....	(d)
Sulphate	.....	6,973	.....	(d)	.....	(d)
Bitartrate (argol)	.....	7	.....	(d)	.....	(d)
Carbonate	.....	1,934	.....	(d)	.....	(d)
Chlorate	.....	(d)	525	$475,434	696	$534,491
Cyanide	.....	460	.....	(d)	.....	(d)
Hydroxide	.....	129	.....	(d)	.....	(d)
Nitrate	.....	23,286	.....	(d)	.....	(d)
All others	.....	10,054	.....	638,768	.....	837,679
	.....	132,729	.....	1,114,202	.....	1,372,170

[a] Fiscal year ending June 30, 1914.
[b] Covers period from July 1 to Dec. 31, 1917.
[c] Quantity not available.
[d] Included in "All others."

PRICES.

Before the European war the most efficient German potash mines could produce 80 per cent muriate containing an equivalent of 50 per cent of potash (K_2O) at about $15 a ton and kainite containing a guaranteed minimum of 12 per cent of potash at less than $2 a ton at the mines. Shipping and other costs amounted to about $3 to $5 a ton. These low costs are illustrated by the prices given in the so-called

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Schmidtmann contracts with several American fertilizer companies in 1909. The contracts covered a period of two years with the privilege of renewal for five years more and called for deliveries of not less than 27,000 tons of potash (K_2O) annually. The Schmidtmann mines, which were among the most efficient in Germany, could probably have operated at these prices, although most of the other German mines could not. The following table shows the Schmidtmann prices and in comparison the prices that were afterward established by the German potash syndicate:

Wholesale prices per short ton of potash salts c. i. f. Atlantic ports, 1910.[a]

Potash salt.	Approximate percentage of potash (K_2O) content.	Schmidtmann prices, 1910.				Syndicate prices, January–June, 1910.			
		Price f. o. b. mines.	Additional charges.[b]	Net price c. i. f. Atlantic ports.	Net price per unit of K_2O.	List price.	Three per cent discount.	Net price.	Approximate net price per unit of K_2O.
Sulphate	48.6	$20.94	$4.86	$25.80	$0.53	$40.00	$1.20	$38.80	$0.80
Muriate	50.0	15.54	4.86	20.40	.41	34.00	1.02	32.98	.66
Manure salts	20.0	3.89	3.24	7.13	.36	12.00	.36	11.64	.58
Hartsalz	16.0	2.48	3.24	5.72	.36	9.00	.27	8.73	.55
Kainite	12.4	1.92	3.24	5.16	.42	7.27	.22	7.03	.57

[a] Federal Trade Commission report on the fertilizer industry, 1916, p. 155.
[b] Includes bagging, insurance, and freight, from mines to Atlantic ports.

In 1910 list prices were increased, but discounts were graded so that for quantities in excess of 20,000 tons of potash (K_2O) they amounted to 15 per cent on muriate, sulphate, and other concentrated salts, and to 15.5 per cent on crude salts (kainite, hartsalz, and 20 per cent manure salts). These prices are shown in the following table:

Wholesale prices per short ton of potash salts c. i. f. Atlantic ports, 1911–1914.[a]

Potash salt.	Approximate percentage of potash (K_2O).	1911–1913			1914[b]			
		List price.	Discount.[c]	Net price.	List price.	Discount.[c]	Net price.	Approximate net price per unit of potash (20 pounds of K_2O).
Sulphate	48.6	$46.30	$6.95	$39.35	$47.58	$7.14	$40.43	$0.83
Muriate	50.0	38.05	5.71	32.34	39.07	5.86	33.21	.66
Manure salts	20.0	13.30	2.06	11.24	13.58	2.10	11.48	.57
Hartsalz	16.0	10.65	1.65	9.00	10.87	1.68	9.19	.57
Kainite	12.4	8.25	1.28	6.97	8.36	1.30	7.06	.57

[a] Federal Trade Commission report on the fertilizer industry, 1916, p. 155.
[b] These prices, which were for January to June, 1914, were increased slightly during the latter part of the year. See Oil, Paint, and Drug Reporter, vol. 85, p. 59, 1914.
[c] 15 per cent discount on sulphate and muriate and 15½ per cent on 20 per cent manure salts, hartsalz, and kainite.

As will be observed from the table, net prices to large importers varied from 57 cents per unit (20 pounds of K_2O) for the lowest-

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grade product to 83 cents for sulphate. The list prices, which are generally shown in market quotations in the United States, correspond to 67 cents per unit for the low-grade material and 98 cents for sulphate. Ocean freight rates to the United States on these salts in bulk from Hamburg averaged about $2 per metric ton to northern ports and $2.50 to $2.90 to southern ports.

After the embargo of January 30, 1915, placed on the exportation of potash salts from Germany, the prices of these salts rose rapidly. Early in 1915, market quotations on 80 per cent muriate were around $115 a ton and gradually rose to $500 a ton in December. The quotations in 1916 varied from $300 to $490 a ton, in 1917 from $325 to $450 a ton, and in 1918 from $260 to $350 a ton. These quotations are not indicative of the actual selling price of potash materials, as only limited quantities of muriate were on the market and muriate was at a premium because of its use as a raw material in the manufacture of various refined potassium salts. The actual selling price in the eastern markets of the domestic output was about $4.87 per unit in 1916, $4.79 in 1917, and $4.61 in 1918. These data are shown in the following table. Prevailing prices of the various potassium compounds are discussed under the individual potassium salts, pages 420–439.

Wholesale price of potash in the United States 1915–1918.

Year.	Market quotations of 80 per cent muriate.[a]						Approximate average selling price per unit of K_2O of domestic output.	
	Per short ton of salt.			Per unit of K_2O.			F. o. b. plant.	Eastern markets.
	High.	Low.	Average.	High.	Low.	Average.		
1915	$500	$115	$245	$10.00	$2.30	$5.90	$3.14	$3.64
1916	490	300	415	9.80	6.00	8.30	4.37	4.87
1917	450	325	380	9.00	6.50	7.60	4.29	4.79
1918	350	260	315	7.00	5.20	6.30	4.11	4.61

[a] Quotations for 1915 and 1916 taken from Jour. Ind. and Eng. Chemistry, and for 1917 and 1918 from Oil, Paint, and Drug Reporter.

USES.

Potash is used principally as a fertilizer, particularly in growing cotton, potatoes, tobacco, citrous fruit, and garden truck. It is applied extensively to thin sandy soils in Germany, the United States, Holland, France, and a few other countries. In 1913 more than 90 per cent of the world's production was thus consumed. The centers of consumption in the United States are mainly in the Southeastern States and along the Atlantic seaboard. Potash, in the form of refined potassium salts, is also used in the manufacture of soap, glass, matches, explosives, and pyrotechnics, medicines, for extracting gold from its ores, in dyeing, tanning, electroplating, photography, and as chemical reagents. The uses of the various salts are discussed under the individual potassium salts on pages 420–439.

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POTASH IN RELATION TO THE WAR.

When German supplies of potash were cut off in 1915 accumulated stocks in the United States were sufficient to meet a large part of the needs for that year. Thereafter only small quantities of German potash could be had outside of the Central Powers, and the rest of the world was forced to produce its own supply of potash or else to get along without it. Prices advanced rapidly and were maintained during the war at about six times their normal level. These high prices stimulated production throughout the world. Russia produced considerable quantities of carbonate from wood ashes and sunflowers, India increased her shipments of nitrate, in the Chilean nitrate industry considerable quantities of potassium nitrate were recovered as a by-product, Japan produced potash from several different sources, and many other countries produced more or less potash. But by far the greatest developments took place in the United States.

In 1910 the United States began investigations looking toward a domestic supply. In 1914 when the war broke out in Europe, the potash deposits of Searles Lake, Calif., and of the Nebraska lakes, the alunite deposits of Utah, the kelp beds of the Pacific coast, the leucite rocks of Wyoming, and the greensand deposits of New Jersey were all known and had received more or less attention. No production had been reported, however, and no potash plants had been installed. The potash industry of the United States had its beginning in 1914, when American Potash (Inc.), of Long Beach, Calif., made a small production from kelp. This was a direct outgrowth of the European war. In 1915, 1,090 short tons of actual potash was produced. Thereafter the number of sources increased and the production rose rapidly. The developments are briefly summarized in the table on page 386. Among the most important new sources developed during the war are the by-product sources—cement plants, blast furnaces, molasses distilleries, and beet-sugar refineries—which are capable of yielding a large part of our domestic needs and which appear to offer the best possibility of development on a basis of permanent competition. The supply of potash in the United States was normal in 1914, and probably half the normal supply was available in 1915. Imports and production amounted to 17,605 tons in 1916, 40,673 tons in 1917, and 62,760 tons in 1918.

The curtailment of potash in fertilizers in Allied countries and especially in the United States during the war was a serious handicap in the production of cotton, tobacco, potatoes, garden truck, and certain other crops, while its increased consumption in Germany and Austria aided those countries greatly in the production of food.

Potassium nitrate is an essential constituent of all black powder, approximately 11,500,000 pounds of which were manufactured for the Ordnance Department during the war. For military purposes black powder containing about 74 per cent of potassium nitrate is used (1) as an ignition charge for igniting the propellant charge of smokeless powder, (2) as a base charge for expelling shrapnel shell, (3) in the manufacture of primers and fuses, (4) in saluting and blank fire charges, (5) in time train rings and combination fuses,

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and (6) in mixtures with other kinds of powders for use in small arms ammuntion. Potassium nitrate is also used to a minor extent in the preparation of pyrotechnics.

Potassium chlorate is used extensively in the preparation of primers, caps, and detonators in combination with fulminate of mercury. Approximately 245,250 pounds was used by the United States for this purpose during the war, and a considerable supply was accumulated for expected use.

Very pure potassium carbonate is an essential raw material in the manufacture of optical glass, which was produced in the United States on a large scale during the war for use in searchlights, reflectors, field glasses, and optical instruments of all kinds. The optical glass industry, which was an outgrowth of the war, experienced much difficulty in obtaining supplies of potassium carbonate suitable for its purpose and depended, at first, on small reserve stocks until domestic firms were able to meet the demand.

Certain other potassium salts found some application during the war, as, for instance, small quantities of potassium perchlorate were used in explosives and pyrotechnics, and pure crystals of Rochelle salt (potassium sodium tartrate) were used for their electrical properties in detectors and sound amplifiers.

CRISIS IN THE AMERICAN POTASH INDUSTRY.

When the armistice was signed in November, 1918, only a few large producers in the United States had made their original investments out of the potash industry, many plants had been operated only a short time, and others were under construction. About one-third of the potash produced in 1918 was still in the hands of producers, money for operating expenses had been advanced on the potash held in storage, and developments had gone forward under the prevailing price of $4 to $5 per unit of potash. Anticipation that low-priced potash from foreign sources would be available followed the armistice agreement, checked sales of domestic potash, and caused the price to fall to about $2.50 per unit—a price lower than the cost of production of many producers. These conditions caused a crisis in the potash industry, and producers began to close their plants. By the early part of 1919 nearly all producers had shut down and some had gone out of business.

DISTRIBUTION OF POTASH IN NATURE.[1]

Potash is widely disseminated in nature, occurring in rocks, soils, saline residues, the ocean, the waters of rivers and lakes, and the tissues of plants and animals. It is an essential constituent of the rock-forming minerals feldspar, orthoclase, mica, leucite, nephelite, and glauconite, and it constitutes 2.99 per cent of igneous rocks, 3.24 per cent of shales, 1.31 per cent of sandstones, 0.48 per cent of soils, and 0.33 per cent of limestones, and averages 2.98 per cent of the entire crust of the earth. Enormous deposits of potash-rich silicate rocks occur in the United States, Italy, and elsewhere. The potash reserves in a number of such deposits in the United States are indicated on pages 408–409.

[1] Compiled largely from Clarke, F. W., The data of geochemistry, 3d ed.: U. S. Geol. Survey Bull. 616, 1916.

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Although silicate rocks contain potash in an insoluble combination and in a form which is not available for industrial use, they are gradually decomposed on exposure to the weather. The potash, thus rendered soluble, is dissolved by rain or ground water, and it finally reaches the ocean or inclosed drainage basins through streams or is absorbed from percolating water by clays.

River waters of North America contain an average of 281 parts per million dissolved salts, of which an average of 1.77 per cent is potassium. They carry annually to the ocean 8,339,800 metric tons of potassium, and the river waters of the world carry 57,892,000 metric tons. The annual precipitation of potassium in insoluble form in the ocean is 50,320,000 metric tons, leaving an annual gain of potassium by the ocean of 7,662,000 metric tons. The total potassium content of the ocean is 510,800,000,000,000 metric tons. Ocean water contains 3.30 per cent of salts, of which 1.11 per cent is potassium, corresponding to 1.38 per cent of potash (K_2O).

Practically all salt deposits contain potash, but generally in very small quantity. Some salt deposits are unusually rich in potash, and they furnish practically the entire world's output. The principal known deposits are those in Germany, Alsace, Spain, Galicia, Abyssinia, Searles Lake, Calif., and Nebraska. Estimates place the potash (K_2O) in the deposits in Germany at 2,000,000,000 tons, in Alsace at 300,000,000 tons, in Searles Lake at 20,000,000 tons, and in the other deposits at much smaller quantities. The approximate potash content of these deposits according to present knowledge is shown in the following table:

Potash reserves in commercial deposits.

	Character of raw material.	Approximate percentage of potash (K_2O) in the crude dried salts.	Potash in reserve in tons of K_2O.
Germany	Salt	15	2,000,000,000
Alsace	do	22	300,000,000
Searles Lake, Calif.	Brine	7	20,000,000
Spain	Salt	15	[a] 30,000
Nebraska	Brine	25	[a] 500,000
Abyssinia	Salt	24	[a] 200,000
Galicia	do	10	[a] 40,000

[a] Estimate indefinite and inconclusive.

POTASH FROM SALINES.

NEBRASKA LAKES.

Nebraska lakes furnished by far the largest output of potash from a single source in 1918. The production amounted to 116,662 short tons of crude material containing 28,854 tons of potash (K_2O). This quantity represented 53 per cent of the total domestic output of potash (K_2O) and approximately twice the production from Nebraska in 1917. The sales in 1918 amounted to 57,522 tons of crude salts, containing 14,011 tons of potash (K_2O), valued at $5,098,023. The value corresponds to an average of $4.11 per unit at point of shipment, compared with $4.04 per unit in 1917. The prod-

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uct marketed consisted of the solids obtained by evaporating the brine and contained from 20 to 28 per cent of potash (K_2O), or an average of nearly 25 per cent. Nineteen companies reported production. Eight of these are located on the Chicago, Burlington & Quincy Railroad and have capacities ranging from about 50 to 200 short tons of crude potash a day. Four large plants, which reported production in 1917 were practically in continuous operation throughout the year. Of four additional large plants, one was in operation about six months, and the three others only for a short time. Eleven small plants are located from 3 to 15 miles from the railroad and have capacities ranging from 3 to 10 tons of crude salts a day. Three of these plants were in operation throughout the year and eight were in operation for only a few months.

The quantity of potash in the Nebraska field is not known. The brines are obtained for the most part at a depth of about 12 feet from sands underlying small lakes scattered through an area of about 800 square miles in the sand-hill region. Those so far worked contain from 2 to 15 per cent of solids. The productive area under the lakes varies greatly. It underlies a large part of some lakes, but usually only a small portion of the subsurface sands contain commercial brines. Explorations are made by sinking wells beneath the surface waters, which is rather difficult and often unsatisfactory and inconclusive. Furthermore, a few wells sunk in valleys at some distance from the lake have encountered brines that might be considered commercial, the quality indicating that the productive area might possibly extend far beyond the lakes themselves and even in some localities where there are no lakes. Under these conditions an estimate of the quantity of commercial potash brines in the Nebraska region is not only very difficult but exploration has not yet extended far enough to make any estimate conclusive. Early in 1918 Condra[1] thought that productive brines would be greatly reduced in four years if the rate of production at that time was continued. This estimate corresponded probably to a total output of 100,000 tons of potash (K_2O). Other estimates have varied greatly. From a study of the whole region in which the productive area of all the known potash lakes and the composition of the brines are taken into account it seems probable that the Nebraska lakes contain several hundred thousand tons and possibly half a million tons of actual potash in brines that run 1 per cent or higher in salts. This quantity would probably keep the plants now constructed in operation for 10 years.

The following firms produced potash from the Nebraska field in 1918:

Acme Potash Co., Antioch, Nebr.
Alliance Potash Co., Antioch, Nebr.
American Potash Co., Antioch, Nebr.
Byrn Potash Co., Antioch, Nebr. (now owned by the Omaha Potash & Refining Co.).
Great Northern Potash Co., Antioch, Nebr.
Home Potash Co., Alliance, Nebr.
Hord Co., Lakeside, Nebr.

[1] Condra, G. E., Preliminary report on the potash industry in Nebraska: Nebraska Conservation and Soil Survey Bull. 8, p. 36, 1918.

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Liberty Potash Co., Antioch, Nebr.
Lincoln Potash Co., Antioch, Nebr.
National Potash Corp., Antioch, Nebr.
Nebraska Potash Works Co., Antioch, Nebr.
Nebraska-Wyoming Potash Co., Antioch, Nebr.
Omaha Potash & Refining Co., Lakeside, Nebr.
Pioneer Potash Co. (formerly Wilson Potash Co.), Antioch, Nebr.
Potash Reduction Co., Hoffland, Nebr.
Robbins Potash Works, Antioch, Nebr.
Rogers, Smith Potash Co., Antioch, Nebr.
Standard Potash Co., Lakeside, Nebr.
Western Potash Works, Antioch, Nebr.

Companies with plants under construction at the close of 1918 were:

Fenner Potash Co., Alliance, Nebr.
Hawkeye Potash Co., Antioch, Nebr.
Pioneer Potash Co. (formerly Wilson Potash Co.), Antioch, Nebr.
William Berg Co., Merriman, Nebr.

Two companies constructed plants which were shut down after a short run. These were the Burnham Potash Co., Antioch, Nebr., and the Commonwealth Potash Co., Birdsell, Nebr.

SEARLES LAKE, CALIF.

Searles Lake, Calif., furnished the second largest output of domestic potash from a single source in 1918, the production being nearly double that in 1917. Most of the product contained from 60 to 70 per cent of potassium chloride and about 15 per cent of borax. In the process of manufacture the brine, after partial evaporation to remove a part of the associated salts, is drawn off and allowed to cool, when the commercial product is deposited. A portion of this material is refined to produce high-grade muriate, but most of it has been marketed as of lower grade. The plant of the American Trona Corporation, at Trona, and that of the Solvay Process Co. at Borosolvay, were in operation practically throughout 1918. The capacity of these plants at the end of the year was estimated at 25,000 tons of potash (K_2O) a year. No other plants had been built and none were under construction in 1918.

After the settlement of the controversy concerning the claims of the American Trona Corporation and the promulgation of the potash leasing law in the later part of 1917,[1] that portion of the Searles Lake potash fields which was not owned by nor awarded to the two operating companies, embracing nearly 16,000 acres, was divided into 11 leasing districts. These subdivisions were taken up by various interests, some of which made plans to construct plants for the utilization of the brines, but no actual construction took place.

Estimates indicate that Searles Lake contains the equivalent of 20,000,000 tons of actual potash (K_2O) in a saturated brine associated with soda, borax, salt, and sodium sulphate. The proportion of potash in the dried salts is about 7.2 per cent. The proceesses of extraction are still undergoing changes and so far have not included the manufacture of by-products. Freight rates to eastern markets are much higher than those from foreign deposits. More-

[1] An act to authorize exploration for and the disposition of potassium: 40 Stat., 297; Potash regulations; Dept. Interior Circ. 594.

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over, the potash (K_2O) content of the German and Alsatian deposits ranges from 12 to 20 per cent, the processes of extraction are firmly established, and the cost of production is low. These facts lead to the belief that production at Searles Lake at competitive prices is limited by and is contingent upon the development both of technical processes for the recovery of by-products and of a market for these by-products at profitable prices and upon the removal of the serious handicap of high freight rates, either by rail or boat, to distant markets located in the Eastern and Southern States.

GREAT SALT LAKE, UTAH.

Two companies produced potash salts from the brines of Great Salt Lake, Utah, in 1918, but their combined output was small. The plant of the Utah Chemical Co. is at Potash siding, on the branch of the Salt Lake Route running from Salt Lake City to Saltair. It was designed to recover potash as a by-product in the manufacture of salt. The plant of the Salt Lake Chemical Co., a subsidiary of the Diamond Match Co., is at Grantsville, about 30 miles west of Salt Lake City, on the Western Pacific Railroad. It was designed to handle the lake water primarily for its potash content. The general nature of the operations of these companies was described in the report on potash in Mineral Resources for 1916.

SALDURO MARSH, UTAH.

The Solvay Process Co. produced potash from Salduro Marsh, Utah, in 1918. The product consisted of muriate containing an equivalent of about 42 per cent of potash (K_2O). Being practically free from carbonates and sulphates and containing magnesium salts, the potash brines of Salduro are similar in type to the artificial potash brines of the German potash works. Although the exact process adopted by the company at Salduro is not disclosed, it is presumed to be similar to the refining processes used in Germany. No estimate of the potash reserve in Salduro Marsh is available, but the quantity is believed to be small. The Solvay Process Co. transferred its interest at the end of 1918 to the Utah-Salduro Potash Co., a subsidiary, and no other developments have been recorded.

SEA-WATER BITTERNS.

The Oliver Chemical Co., Mount Eden, Calif., and the Whitney Chemical Co., San Mateo, Calif., each reported a small production of potash from sea-water bitterns in 1918. The product contained from 12 to 45 per cent of potash (K_2O). Several plants on the Pacific coast produce salt from sea water, and the residual mother liquor contains from 2 to 8 per cent of potash (K_2O). The quantity of such liquor available for the production of potash is not known, but is believed to be too small to yield a large output.

MISCELLANEOUS.

The United Mineral Products Co. produced a small quantity of crude potash in 1918 from brine obtained by sinking shallow wells into the dry bed of an old lake near Hartsell, Colo. Apparently the flow of brine is weak and the supply is meager.

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A general summary of explorations for potash was included in the report for 1917. Explorations in 1918 have not revealed any new sources of supply and have not resulted in any extensive developments.

POTASH FROM ALUNITE.

Potash materials produced and sold from alunite in 1918 amounted to 6,180 short tons containing 2,621 tons of potash (K_2O), valued at $1,276,774 at the point of shipment, or at $4.87 per unit of K_2O. The quantity represented 5 per cent of the total domestic production of potash (K_2O), and was a slight increase over the production from alunite in 1917. The product consisted for the most part of high-grade sulphate containing about 51 per cent of K_2O. Small quantities, both of alum containing about 10 per cent K_2O and of calcined alunite containing from 4.5 to 13 per cent of K_2O, were also produced and shipped. The entire output came from the alunite deposits in the vicinity of Marysville, Utah. Four companies reported production from this field in 1918. One company produced high-grade sulphate, one produced alum, one produced calcined alunite at the Florence calcining plant at Marysville, and one shipped raw alunite to Harvey, La., for calcining.

The most important developments in 1918 consisted in the completion at Marysvale of the plant of the Mineral Products Corporation, which had burned in the later part of 1917; the construction of a plant for the manufacture of alum from alunite at Murray, Utah, by the American Smelting & Refining Co.; and the building of a calcining plant for the treatment of alunite at Harvey, La., by Swift & Co.

The quantity of alunite available for potash is not known. Estimates place the quantity in one group of claims to a depth of 100 feet at 475,000 tons and indicate the probable depth of the deposit at 1,000 feet.[1] The quantity of alunite of good quality in other claims is largely a matter of conjecture.

Production of potash from Marysvale, Utah, in 1918 was reported by the following companies:

American Smelting & Refining Co., Murray, Utah.
Caraleigh Phosphate & Fertilizer Works, Raleigh, N. C.
Mineral Products Corporation, Marysvale, Utah.
Swift & Co., Harvey, La.

Considerable exploration and development work was done in 1918 on the alunite claims at Sulphur, Nev., and Rico, Colo., but no production was reported from these properties.

POTASH FROM BLAST FURNACES.

Four steel companies—the Bethlehem Steel Co., South Bethlehem, Pa.; the Carnegie Steel Co., Pittsburgh, Pa.; the Thomas Iron Co., Hokendauqua, Pa.; and the Tennessee Coal, Iron & Railroad Co., Birmingham, Ala.—marketed potash materials from blast-furnace dust in 1918. Most of the product contained from 6 to 9 per cent of water-soluble potash (K_2O) and represented merely the dust that settled in the stoves and boiler flues, where the blast-furnace gases are finally consumed. A small quantity of potassium sulphate was also produced.

[1] Loughlin, G. F., Recent alunite developments near Marysvale and Beaver, Utah: U. S. Geol. Survey Bull. 620, pp. 237–270, 1916.

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The present estimates of the recoverable potash from blast-furnace gases are based on inconclusive evidence and range from 50,000 to 200,000 tons of potash (K_2O) annually. Plants now being installed are expected to demonstrate the commercial feasibility of saving the potash from this source. Cottrell dust-collecting systems for recovery of potash are being built at the plant of the American Manganese Manufacturing Co., Dunbar, Pa., and the Lochiel furnace, Harrisburg, Pa.

POTASH FROM CEMENT MILLS.

Potash materials produced as a by-product in the manufacture of cement in 1918 amounted to 12,652 short tons containing 1,549 tons of potash (K_2O). This quantity represented 3 per cent of the total output of potash in the United States and was a slight decrease from that reported in 1917. The sales amounted to 11,172 tons of potash materials containing 1,366 tons of potash (K_2O), valued at $539,567. The product marketed consisted of about equal parts of dust containing 2 to 10 per cent of potash and of potassium sulphate containing 25 to 62 per cent of potash. Twelve cement mills reported production in 1918. Seven of these mills had installed potash-recovery plants, including leaching and evaporating systems, and marketed potassium sulphate. Four mills had installed dust-collecting systems and marketed cement dust for incorporation into fertilizers. One mill had installed no potash plant but marketed a small quantity of dust that had collected in the flues and under the stacks.

The 11 cement mills with potash-recovery plants which reported production of potash in 1918 produced 6,165,000 barrels of cement, from which 6,560 tons of potash K_2O were recoverable. Seven of these mills were in operation throughout the year except when shut down from lack of fuel, or because of alterations or repairs, and four were in operation only a short time.

Developments in 1918 included putting into operation four new potash-recovery plants in cement mills, practical completion of construction of plants in five mills, beginning of construction in two other mills, and installation of waste-heat boilers in connection with potash-recovery plants in some mills.

About 110 cement mills in the United States produce annually about 90,000,000 barrels of cement, 70 per cent of which comes from Eastern States contiguous to large centers of consumption of potash. Estimates place the potash recoverable as a by-product in the cement industry at about 75,000 tons of K_2O annually.

Cement manufacturers which reported production of potash in 1918 are as follows:

Alpha Portland Cement Co., Cementon, N. Y.
Atlas Portland Cement Co., New York, N. Y.
California Portland Cement Co., Colton, Calif.
Coplay Cement Manufacturing Co., Coplay, Pa.
Dexter Portland Cement Co., Nazareth, Pa.
Newaygo Portland Cement Co., Newaygo, Mich.
Ogden Portland Cement Co., Ogden, Utah.
Portland Cement Co., of Utah, Salt Lake City, Utah.
Riverside Portland Cement Co., Riverside, Calif.
Santa Cruz Portland Cement Co., Davenport, Calif.
Security Cement & Lime Co., Hagerstown, Md.
Southwestern Portland Cement Co., Victorville, Calif.

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At the end of 1918 potash-recovery plants were under construction by the following cement mills, the first three being practically completed:

Clinchfield Portland Cement Corp., Kingsport, Tenn.
Ironton Portland Cement Co., Ironton, Ohio.
Louisville Cement Co., Sellersburg, Ind.
Aetna Portland Cement Co., Fenton, Mich.
Peninsular Portland Cement Co., Cement City, Mich.

POTASH FROM SILICATE ROCKS.

Potash materials were produced from greensand in 1918 by two experimental plants—one producing caustic potash and the other muriate. The actual production was small, and the figures are included with those from blast furnaces. The producing companies were the Eastern Potash Corporation (formerly the Kaolin Products Corporation), Jones Point, N. Y., and the Atlantic Potash Co., Stockertown, Pa. A description of the operations of these companies was included in the report for 1917.

R. S. Ryan & Co. constructed a commercial plant at Reeves station, near Medford, N. J., for the extraction of potash from greensand by the Tschirner process.[1] The Liberty Potash Co. built a plant at Green River, Wyo., said to have cost $1,000,000, for the extraction of potash from leucite rocks by the Boyer-Sterling process,[2] and the National Process Co., which is affiliated with the Louisville Cement Co., began construction of a plant at Louisville, Ky., for the extraction of potash from shales. The Georgia Potash & Chemical Co. acquired a large acreage of the Georgia shales and control of the Cottrell patents as applied to Southern States. Other companies have been active and considerable experimental work has been done, but so far as known to the United States Geological Survey, no other commercial plants were under construction at the end of 1918.

Among the raw materials to be considered in connection with the extraction of potash from silicate rocks are the deposits of greensand[3] (glauconite) in New Jersey, Delaware, and Maryland, which carry about 7 per cent of potash; the feldspar deposits from Maine to North Carolina;[4] the potash-bearing rocks of the Leucite Hills in Sweetwater County, Wyo.,[5] which carry about 10 per cent of potash; sericites and slates of Georgia, said to contain about 9 per cent of potash;[6] and the tailings[7] collected in certain dumps at copper and gold mines in the West, which carry probably from 5 to possibly as much as 10 per cent of potash. Feldspar often contains from 10 to 14 per cent of potash (K_2O), but a series of analyses (unpublished) by the United States Geological Survey indicates that the average quarry product rarely contains more than 7 to 7.5 per cent.

[1] U. S. patents 1,254,450 and 1,254,451, Brit. patent 117,870.
[2] U. S. patents 1,264,572 and 1,268,508.
[3] Ashley, G. H., Notes on the greensand deposits of the eastern United States: U. S. Geol. Survey Bull. 660, pp. 27–58, 1917.
[4] Bastin, E. S., U. S. Geol. Survey Bull., 420, 1910. Watts, A. S., Bur. Mines Bull. 53, 1913; Bull. 92, 1916.
[5] Schultz, A. R., and Cross, Whitman, Potash-bearing rocks of the Leucite Hills, Wyo.: U. S. Geol. Survey Bull. 512, 1912.
[6] McCallie, S. W., Eng. and Min. Jour., vol. 104, p. 643, 1917. Also Shearer, H. K., The slate deposits of Georgia: Georgia Geol. Survey Bull. 34, 1918.
[7] Butler, B. S., Potash in certain copper and gold ores: U. S. Geol. Survey Bull. 620, pp. 227–236, 1916.

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No estimates of quantity for feldspar and sericite are available, but the quantity of these materials is known to be very large. Washington[1] estimates the potash in the greensands of New Jersey at 2,034,000,000 metric tons. Schultz and Cross estimated the potash in the Leucite Hills of Wyoming at 197,000,000 tons. Butler's figures indicate that in 1914 more than 100,000,000 tons of mill tailings had accumulated in the dumps at copper and gold mines, and that many hundred million tons of unmined ore had been developed. These data are sufficient to show the magnitude of the supply of this class of raw materials.

Many processes have been devised for the extraction of potash from silicate rocks, some of which have been subjected to experimental tests. United States patents covering such processes were listed in the annual report on potash for 1917. Those granted in 1918, and also foreign patents for 1918, are listed below. Printed copies of United States patents may be obtained from the United States Patents Office for 5 cents each.

United States patents for processes for extracting potash from silicate rocks.

1253560, Jan. 15, 1918, Anderson, E. L. Feldspar is mixed with carbon and electrolized in a solution of H_2SiF_6 to produce KOH.

1254450, Jan. 22, 1918, Tschirner, F. Glauconite is subjected to an oxidizing roast with CaO and $Ca(OCl)_2$ and leached to produce KCl.

1254451, Jan. 22, 1918, Tschirner, F. Greensand marl, lime sand, and calcium chloride are roasted at about 800° C. to convert the potassium into soluble form.

1254676, Jan. 29, 1918, Glaeser, W. Glauconite, calcium chloride, and coke, or similar materials, are heated to drive off combined water (270°) and the dry mixture then heated to about 800° C. in a nonoxidizing atmosphere to produce KCl and the silicate of iron and calcium.

1254677, Jan. 29, 1918, Glaeser, W. Feldspar, or other potash-bearing silicate, is mixed with an equal quantity of calcium chloride and about 5 per cent of FeO. It is then dried and heated to about 900° C. in a nonoxidizing atmosphere to produce KCl.

1256295, Feb. 12, 1918, Charlton, H. W. Feldspar is mixed with calcium carbonate in water in the proper proportion and heated under pressure above 200 pounds per square inch to convert the potassium into soluble form and to leave the insoluble residue suitable for the manufacture of a steam-hardening cement.

1260944, Mar. 26, 1918, Rody, F. A. Silicates, such as feldspar and leucite, are fused and reduced to a fine powder and then digested for about an hour with milk of lime under pressure, to bring the alkali into soluble form.

1263705, Apr. 23, 1918, Rody, F. A. Feldspar, leucite, or other similar silicate is heated to a sintering temperature with CaO and Na_2CO_3 and the product is boiled with water to dissolve the alkali.

1264572, Apr. 30, 1918, Sterling, G. Potash-bearing silicates are heated to about 1,400° C. with lime and the mother liquor salts from salt brines, and the potassium salts are sublimed and condensed.

1264949, May 7, 1918, Lindblad, A. R. Powdered feldspar, or other potash-bearing silicate, is mixed with carbon and lime and fused in an electric furnace. A part of the potash forms potassium cyanide and a part is volatilized and afterward collected.

1268508, June 4, 1918, Sterling, G. Feldspar or other potash-bearing silicate, mixed with calcium carbonate and sodium sulphate, is heated to a temperature just below vitrification and K_2SO_4 is sublimed and condensed.

[1] Washington, H. S., Italian leucite lavas as a source of potash: Met. and Chem. Eng., vol. 18, p. 71, 1918.

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1270515, June 25, 1918, Haslup, E. W., and Peacock, B. A. Potash-bearing silicate rock and phosphate rock are treated with H_2SO_4 in a closed vessel at a temperature of from 200° to 300° C., and the residue lixiviated with water and the solution neutralized with alkali metal carbonate or hydroxide and the potassium and phosphorus compounds finally recovered by crystallization.

1277773, Sept. 3, 1918, Swenarton, W. H. Powdered feldspar is fused with K_2CO_3 at 800° to 1,200° C. for an hour, and the pulverized melt is digested with hot water and after separating the alumina the potassium salt is finally obtained by crystallization.

1279145, Sept. 17, 1918, Peacock, B. A. Powdered glauconite is heated with a slight excess of $Al_2(SO_4)_3$ to a temperature of from 200° to 250° C. to form K_2SO_4 and the latter is recovered by extraction with water.

1279109, Sept. 17, 1918, Haslup, E. W., and Peacock, B. A. Powdered greensand and bauxite are mixed with sulphuric acid and allowed to stand from 24 to 48 hours in a closed vessel, and the sulphates thus formed are extracted with water and alum is finally crystallized from the solution.

Canadian patents for processes for extracting potash from silicate rocks.

170834, July 18, 1916, Peacock, S. A silicate is melted in a closed furnace and a sufficient quantity of alkali is added to react with all the silicate to form a soluble alkali silicate.

174119, Dec. 26, 1916, Heyman, A. W. Alkali silicates are heated with a calcareous material until practically free from chloride and then leached with water through which carbondioxide is passed.

174704, Jan. 30, 1917, Frazer, J. C. W., and Mitler, E. The silicate is treated with caustic alkali so that a portion of the silica is removed as a soluble alkali silicate leaving a residual silicate readily decomposable by mineral acid.

176939, May 8, 1917, Blumenberg, H., jr. A process of extracting potassium from minerals by heating powdered feldspar mixed with an equal part of sodium nitrate to a temperature from 1,200° to 1,500° C. in a closed vessel until the liberation of nitric acid ceases and then treating the cooled groundmass with mineral acids.

179629, Oct. 9, 1917, Hone, A. D. Silicates are decomposed by using a fluoride and an acid and the potash is finally separated as potassium sulphate.

183238, Mar. 26, 1918, Swenarton, W. H. Finely ground feldspar is fused with K_2CO_3 at 800° to 1,200° C. and the cooled mass ground and digested with water which dissolves the potassium.

186421, Sept. 3, 1918, Halvorsen, B. F. Potash-bearing silicate is heated with CaO, C. and N or with CaC_2 and N, or with $Ca(CN)_2$, to a temperature above 700°C. with the production of a K–N fertilizer which may be treated further to expel the N.

186422, Sept. 3, 1918, Halvorsen, B. F. Potash-bearing silicate is heated with $CaCN_2$ in the presence of superheated steam and the resultant soluble compounds of potassium are recovered.

British patents for processes for extracting potash from silicate rocks.

109105, Sept. 5, 1916, Schmidt, W. A. Mineral silicates, such as feldspar, are roasted in the presence of lime or other alkali earth and preferably also in the presence of sulphur dioxide ond oxygen, whereby the potassium is volatilized and finally condensed and collected.

113211, June 5, 1917, Ashcroft, E. A. Silicates, such as feldspar, leucite, etc., are ground, fused with NaCl or other alkali chloride with the exclusion of air and moisture, and the cooled mass finally lixiviated with water, from which potassium chloride is obtained by evaporation and crystallization.

114743, July 20, 1917, Ashcroft, E. A. Potash feldspar may be treated at a suitable temperature and pressure with lime or magnesia and water or steam with the production of a solution of KOH and a residue suitable for the manufacture of cement.

116118, May 9, 1917, Hone, A. D. Potash-bearing silicate is treated with H_2SO_4 and fluorspar or other fluoride sufficient to liberate HF in such quantity as to remove the Si as tetrafluoride.

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116438, Oct. 16, 1917, Dutt, E. E., and Dutt, P. C. Powdered feldspar is heated to a temperature of 700° to 900° C. in a retort into which vapors of $AsCl_3$ are passed. The As_2O_3 distills off, and KCl is obtained by lixiviating the residue and evaporating the solution.

117755, Nov. 5, 1917, Scholes, S. R. Feldspar or other potash mineral is fused with sodium or potassium carbonate, and the ground melt is boiled with water and treated with CO_2 or with cement kiln gases, and the solution is filtered off and evaporated with the production of potassium carbonate.

117870, Nov. 2, 1917, Sschirner, F. Glauconite is heated with lime, sand, chalk, marble, common marl, $CaCO_3$, or corresponding compounds of Mg, Ba, or other alkalies or alkaline earths, and with $CaCl_2$ or NaCl or HCl gas to a temperature of about 800° C. and the product is leached to obtain KCl.

French patent for process for extracting potash from silicate rocks.

483912, August 21, 1917 (see Brit. 103290), Jungner, E. W. The production of alkali carbonate and hydraulic cement from silicates.

Japanese patent for process for extracting potash from silicate rocks.

32516, Apr. 15, 1918, Jungner, E. W. Powdered alkali silicate is heated with lime and coal in the presence of CO_2, flue gas or air to a temperature at which the alkali chloride is driven off.

POTASH FROM KELP.

Kelp yielded 14,029 short tons of potash materials in 1918 containing 4,804 tons of potash (K_2O), which represented 9 per cent of the total domestic output of potash (K_2O). The output was practically all sold and was valued at $2,296,983. About 60 per cent of the product consisted of refined muriate, and nearly all of the remainder consisted of kelp ash and ground kelp. Eight companies, including the Government experiment plant at Summerland, Calif., reported production. Seven of the plants are in southern California and were in operation in 1917; one is in Washington and began operations in the latter part of 1918.

The companies which reported production of potash from kelp during 1918 are as follows:

Hercules Powder Co., Chula Vista, Calif.
Diamond Match Co., Wilmington, Calif.
Sea Products Co., Long Beach, Calif.
Pacific Products Co. of California, Long Beach, Calif.
Swift & Co., San Diego, Calif.
Lorned Manufacturing Co., Summerland, Calif.
United States Department of Agriculture, Summerland, Calif.
Puget Sound Kelp & Fertilizer Co., Seattle, Wash.

The Occidental Chemical Co. (formerly the California Chemical Co.), Summerland, Calif; San Simeon Reduction Co., San Simeon, Calif.; and the Southern Reduction Co., San Diego, Calif., were in operation during 1917, but reported no production in 1918.

Reports indicate that the kelp-potash producers closed their plants early in 1919 and later most of them were dismantled in anticipation of prices at which they could not compete, the governmental plant being the only one that continued in business. Available supplies of easily accessible kelp on the Pacific coast are sufficient to yield probably between 5,000 and 10,000 tons of actual potash (K_2O) annually. The capacity of the kelp-potash plants in 1918 was about 5,000 tons. Revival of the industry apparently will depend on the recovery of

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by-products such as iodine, acetone, ammonia, and charcoal by methods that are being investigated by the Department of Agriculture experimental plant at Summerland.

POTASH FROM MOLASSES DISTILLERY WASTE.

Eight companies produced and sold from molasses distillery waste 11,792 tons of potash materials in 1918, containing 3,467 tons of actual potash (K_2O), valued at $1,335,516. The production represented an increase of about 22 per cent in K_2O over that in 1917. The products consisted for the most part of ash and crude potash salts containing from 24 to 38 per cent of K_2O. Small quantities of materials containing less than 20 per cent of K_2O were also marketed.

The following firms, the last three of which made only small experimental production during the first half of the year, reported production in 1918:

Mason By-products Co., San Francisco, Calif.
Western Industries Co., Agnew, Calif.
Mifflin Chemical Corporation, Philadelphia, Pa.
Puerto Rico Distilling Co., Arecibo, P. R.
Jefferson Distilling & Denaturing Co., Harvey, La.
United States Industrial Alcohol Co., New Orleans, La
Northern Alcohol Co., Billings, Mont.
Joslin Schmidt Co., Cincinnati, Ohio.

Estimates place the potash (K_2O) which could be recovered annually in the United States as a by-product in the manufacture of industrial alcohol from molasses at 30,000 tons. More than 80 per cent of this potential supply of potash, now lost, is contiguous in the Eastern States to large centers of the consumption of potash.

POTASH FROM STEFFENS WASTE WATER IN BEET-SUGAR MANUFACTURE.

The recovery of potash from the large quantities of beet molasses now annually reworked for sugar, chiefly by the Steffens process, received considerable attention in 1918. Eight companies reported production from this source during the year 1918, amounting to 8,795 tons of crude materials, containing 1,374 tons of potash (K_2O). This quantity of potash is more than three times that produced in 1917 from this source. The sales amounted to 3,650 tons of crude materials containing 742 tons of potash (K_2O), valued at $267,309. The product consisted of concentrated potash liquors and potash char. Concentrated liquors containing from 7.5 to 11 per cent of potash, obtained by evaporating Steffens waste liquors, were produced by three companies. Potash char, containing from 32 to 42 per cent of potash, obtained by evaporating the waste liquors and charring the residue, was produced by five companies. A small quantity of crude potassium sulphate, containing 35 per cent of potash (K_2O), was also produced. The following companies reported production in 1918:

American Beet Sugar Co., Oxnard, Calif.
Spreckels Sugar Co., San Francisco, Calif.
Great Western Sugar Co., Denver, Colo.

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Columbia Sugar Co., Bay City, Mich.
Holland-St. Louis Sugar Co., Decatur, Ind.
Holly Sugar Corporation, Huntington Beach, Calif.
Larrowe Construction Co., Mason City, Iowa.
United Engineering Co., Blissfield, Ind.

The Great Western Sugar Co. constructed a plant during 1918 at Scotts Bluff, Nebr., for recovering potash from Steffens waste waters from the sugar refineries at Scotts Bluff and Gering.

Potash (K_2O) which could be recovered and which is now going to waste in Steffens water from beet-sugar refineries is estimated at 8,000 tons. Steffens waste waters are very dilute and require the evaporation of large volumes of water in order to recover the potash. The cost of production is in consequence rather high. Dry distillation of the residue from Steffens waste liquor with the production of cyanides, ammonia, fuel gases, and other products whereby both the organic and inorganic constituents are conserved, may eventually result from efforts to recover the potash. The problem of saving both the potash and the nitrogen deserves careful consideration.

POTASH FROM WOOD ASHES.

Fifty-one firms reported the production in 1918 of 1,100 short tons of crude potash from wood ashes, estimated to contain 673 tons of pure potash. The production was a slight increase over that for 1917, which was 1,035 tons of crude potash. The sales amounted to 1,063 tons of crude potash, containing 651 tons of potash (K_2O), valued at $549,745. In 1918 the output consisted of 914 tons of crude potassium carbonate containing 533 tons of K_2O, and 186 tons of caustic potash containing 140 tons of K_2O. The following firms reported production from this source during the year:

INDIANA.

Indiana Chemical Co., Ellettsville.

MAINE.

Fairfield Potash Manufacturing Co., 180 Main Street, West Benton.
Maine Potash Co., Keekan.

MICHIGAN.

Anderson Bros., Route 1, Box 150, Traverse City.
Baraga Potash Co., Baraga.
Boyne City Potash Co., Boyne City.
Burley, Wm. C., & Co., Munising.
Campbell, Wm. T., Potash Co., Trout.
East Jordan Potash Co., East Jordan.
Escanaba Potash Co., Escanaba.
Gaylord Potash Co., Gaylord.
Iron Mountain Potash Factory, Iron Mountain.
Isham & Isham, Detroit.
Johnson, Albin, Jennings.
Manistique Potash Co., Manistique.
McClory, James, 115 East Spratt Street, Alpena.
Menominee Potash Co., Menominee.
Monroe Chemical Co., 211 Hammond Building, Detroit.
Peter Bloomquist Co., Cadillac.

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Prentice, Orson W., & Son, West Branch.
Riley Potash Factory, St. Johns.
Salling Hanson Co., Grayling.
Schwartz, August, Pellston.
Teachman, G. E., Ithaca.
Thomas, E. A., 400 Wisner Street, Saginaw.
Trapp, R. W., Route 1, Mount Clemens.
Wood, Silas E., Maple Rapids.

OHIO.

Butler, E. W., Napoleon.
Englehart, Phillip, Luckey.

TENNESSEE.

Union Chemical Co., Mallory Branch, P. O., Memphis.

WISCONSIN.

Abbotsford Soap & Potash Co., Abbotsford.
Baldwin Brothers, Oconto.
Cotter Brothers, Park Falls.
Eau Claire Potash Co., Eau Claire.
Erskine Potash Co., Washburn.
Fagon, Henry, Merrill.
Forest County Potash Co., Soperton.
Goodman Lumber Co., Goodman.
Great Northern Manufacturing Co., Antigo.
Heinzkill, John, Appelton.
Ladysmith Potash Co., Ladysmith.
Marinette Potash Co., Marinette.
Mattoon Potash Co., Mattoon.
Medford Potash Co., Medford.
Oshkosh Potash & Chemical Co., Oshkosh.
Phillips Potash Co., Phillips.
Rhinelander Potash Co., Rhinelander.
Wausau Potash Factory, Wausau.
Wausau Soap Co., Wausau.
West Lumber Co., Lugerville.
Wisconsin Potash Co., Shawano.
Wisconsin Potash Co., Tomahawk.

The wood-ash potash industry centers around the hardwood lumber districts of Michigan and Wisconsin. Fresh ashes are required for good results. The districts in Michigan and Wisconsin are thoroughly worked at present, so that production from these States could not be much increased. Conditions in other States with regard to the supply of hardwood ashes are not so well known, but production in many other localities is probably feasible.

Ernest Bateman,[1] of the Forest Products Laboratory, United States Department of Agriculture, Madison, Wis., has made a careful study of the wood-ash potash industry and has estimated that 2,075 tons of K_2O could be produced annually in the United States from easily collectible wood ashes from hardwood sawmills. His figures as related to a number of different States are presented in the following table:

[1] Bateman, Ernest, Wood ashes and production of potash: Met. and Chem. Eng., vol. 20, 1919.

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Estimated possible annual production of potash from wood ashes.

State.	Available annual supply of wood ashes (short tons).	Potash (K_2O) (short tons).	State.	Available annual supply of wood ashes (short tons).	Potash (K_2O) (short tons).
West Virginia	6,800	245	North Carolina	2,400	85
Michigan	6,000	215	Indiana	2,200	80
Arkansas	5,100	185	Missouri	2,000	70
Wisconsin	4,700	170	New York	1,900	70
Tennessee	4,300	155	Vermont	800	30
Kentucky	3,900	140	Texas	700	25
Pennsylvania	3,500	125	Maryland	600	20
Virginia	3,200	115	Maine	500	20
Ohio	3,100	110	South Carolina	500	20
Mississippi	3,000	110			
Louisiana	2,400	85		57,600	2,075

This estimate, which includes only ashes from hardwood sawmills, appears to be conservative. For instance, the table indicates a possible annual production from hardwood ashes in Wisconsin at 170 tons of K_2O, whereas the actual production of potash from wood ashes from all sources in Wisconsin in 1918, as reported to the United States Geological Survey, was 398 tons.

Potash-producing plants as used in Wisconsin, according to Bateman, cost between $3,000 and $4,000, and the cost of manufacturing crude potash ranges from about 7 to 17 cents a pound. It may be reduced under certain conditions to 5 cents a pound and enable the output to compete on a small scale with imported potash.

POTASH FROM WOOL WASHINGS AND MISCELLANEOUS SOURCES.

In 1918 four companies were engaged in producing potash from wool washings and miscellaneous sources. The production and sales amounted to 931 tons of materials, containing 289 tons of potash (K_2O), and was valued at $138,688. The product consisted of refined muriate and of ash containing from 12 to 20 per cent of K_2O. The producing companies were the Diamond Match Co., Lawrence, Mass.; Arlington Mills, Lawrence, Mass.; California Potash Co., Sacramento, Calif.; Neo Manufacturing Co., Reno, Nev. The source of the potash produced by the two western firms was largely vegetable ash.

POTASH FROM FOREIGN SOURCES.

GERMANY.

The potash deposits of Germany, which were discovered by the Prussian Government in 1843 at Stassfurt while boring for rock salt and which occur in upper layers of rock salt in the plains of northern Germany, have been estimated to occupy a volume of 10,790,000,000 cubic meters and to contain 20,000,000,000 metric tons of potash salts, corresponding to about 2,000,000,000 metric tons of potash (K_2O), a quantity sufficient to supply the world for 2,000 years at

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the present rate of consumption. These beds were first exploited about 1860, and have furnished practically the entire world's supply of potash for many years. The total quantity of raw potassium salts mined in Germany, including Alsace, is shown in the following table:

Raw potassium salts mined in Germany,[a] 1861–1917, in metric tons.

Year.	Number of works.[b]	Carnallite.	Kieserite.	Kainite, including hartsalz and schönite.	Sylvinite.	Total.
1861	1	22,930				22,930
1862	2	197,269	203			197,472
1863	2	583,035	683			583,718
1864	2	1,154,085	889			1,154,974
1865	2	876,709	748	13,139		890,596
1866	2	1,355,537	4,135	58,084		1,417,756
1867	2	1,416,042	11,435	89,765		1,517,242
1868	2	1,673,367	14,178	107,717		1,795,262
1869	2	2,118,338	2,265	168,572		2,289,675
1870	2	2,682,256	707	203,008		2,885,971
1871	2	3,359,446	470	365,817		3,725,733
1872	2	4,685,375	225	180,672		4,866,272
1873	2	4,410,786	75	61,013		4,471,874
1874	3	4,149,613	160	97,526		4,247,299
1875	3	4,987,370	50	241,238		5,228,658
1876	3	5,636,691	1,451	179,376		5,817,518
1877	4	7,718,193	1,515	354,768		8,074,476
1878	4	7,357,502	5,198	340,038		7,702,738
1879	4	6,104,270	7,607	502,065		6,613,942
1880	4	5,282,120	8,929	1,394,908		6,685,957
1881	4	7,447,261	20,819	1,583,299		9,051,379
1882	4	10,592,998	46,581	1,484,771		12,124,350
1883	6	9,502,032	117,905	2,288,171		11,908,108
1884	6	7,399,590	122,899	2,171,056		9,694,545
1885	6	6,447,098	119,696	2,723,095		9,290,489
1886	7	6,982,293	139,176	2,473,268		9,594,737
1887	7	8,402,068	141,859	2,376,288		10,920,215
1888	7	8,496,025	107,539	3,755,736	22,203	12,381,503
1889	7	7,987,214	93,540	3,626,110	283,288	11,990,152
1890	8	8,385,256	69,514	4,018,707	319,168	12,792,645
1891	9	8,188,624	58,156	5,124,037	326,612	13,698,329
1892	9	7,367,507	57,825	5,857,748	326,694	13,609,774
1893	10	7,946,597	48,072	6,899,943	491,396	15,386,008
1894	10	8,513,385	38,646	7,293,009	634,949	16,479,989
1895	10	7,829,442	30,121	6,695,319	760,974	15,315,856
1896	11	8,562,230	28,409	8,330,251	903,896	17,824,786
1897	12	8,512,720	26,190	10,121,856	841,046	19,501,812
1898	13	9,909,983	24,443	11,206,157	942,701	22,083,284
1899	13	13,179,475	20,664	10,631,052	1,006,532	24,838,623
1900	15	16,978,032	20,474	11,893,941	1,477,911	30,370,358
1901	21	18,601,891	23,352	14,321,360	1,900,342	34,846,945
1902	24	17,056,646	18,211	13,545,281	1,888,208	32,508,346
1903	28	18,440,365	15,534	15,828,674	1,961,403	36,245,976
1904	28	19,111,660	10,555	19,068,230	2,344,551	40,534,996
1905	35	22,397,099	27,308	24,055,361	2,306,216	48,785,984
1906	39	22,631,972	91,905	27,540,215	2,849,435	53,113,527
1907	45	25,347,888	103,595	27,889,734	3,041,431	56,382,648
1908	53	27,687,939	184,730	29,217,125	3,052,824	60,142,618
1909	63	32,807,264	73,878	32,682,903	3,447,494	69,011,539
1910	72	35,828,853		45,778,932		81,607,785
1911	78	44,416,640		52,648,433		97,065,073
1912	94	52,816,427		57,883,716		110,700,143
1913	125	53,023,505		63,051,600		116,075,105
1914	149	36,507,506		45,207,610		81,715,116
1915	149	30,111,099		38,683,661		68,794,760
1916	148	37,952,024		48,476,848		86,428,872
1917	147	37,673,712		51,713,671		89,387,383

[a] Handbuch der Kali-Bergwerke, Salinen und Tiefbohrunternehmungen, 1918, p. 109, published by the Kuxen-Zeitung, Berlin.

[b] Wohltman, F., Die Anwendung und Beschaffung der kunstlichen Düngemittel nach dem Kriege, p 25, an address delivered on October 12, 1918, at the annual convention of the Halle Association for the Investigation of the Mineral Wealth of Central Germany and its Exploitation, and published as a Separate by Wm. Knapp, Halle, Germany, 1919.

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Although a large part of the crude salts mined are subjected to manufacturing processes to produce higher grade salts before marketing, most of the kainite and some of the sylvinite and other salts are sold as they come from the mines. The sales of manufactured and crude-potassium salts during selected years since 1880 from the German and Alsatian mines are shown in the following table:

Crude and manufactured potassium salts sold from the German and Alsatian mines,[a] 1880–1918, in metric tons.

Year.	Muriate of potash (80 per cent).	Sulphate of potash (90 per cent).	Sulphate of potash and magnesia (48 per cent).	Sulphate of potash and magnesia (40 per cent).	Manure salts.	Kainite and sylvinite.[b]	Total crude and concentrated salts.	Total K_2O.	Value.[c]
1880	96,832	.....	7,000	.....	9,500	127,518	240,850	68,550	.....
1890	134,760	13,839	10,830	907	17,620	305,015	482,971	122,302	.....
1900	206,471	31,255	12,150	932	129,908	1,098,661	1,479,377	303,610	$13,382,815
1910	434,243	93,208	41,529	168	524,874	3,051,258	4,145,280	857,883	35,224,000
1911	443,357	110,123	49,014	144	645,724	3,211,911	4,460,273	939,927	38,680,000
1913	484,254	110,784	58,269	119	956,608	3,577,266	5,187,298	1,110,389	45,696,000
1914	363,293	76,100	54,820	155	854,665	2,589,969	3,939,002	903,988	37,128,000
1915	134,461	5,367	77,329	137	802,872	1,902,735	2,922,901	679,776	25,466,000
1916	113,662	2,963	41,715	141	1,383,373	2,140,933	3,682,787	883,976	38,794,000
1917	294,917	55,561	48,052	105	1,544,215	2,607,745	4,550,595	1,004,281	(d)
1918	(d)	(d)	(d)	(d)	(d)	(d)	(d)	[e]1,056,100	(d)

[a] Compiled from The potash supply with special reference to the United States, pamphlet published by the Kali Syndicate, Berlin, p. 32, 1913; The Potash Industry, pamphlet published by German Kali Works (Inc.), pp. 35, 39, and 40, New York, 1916; Handbuch der Kali-Bergwerke, etc., op. cit., pp. 107, 109, and 111; Wohltmann, F., op. cit., pp. 25, 30.

[b] Includes carnallite and kieserite, 1913–1918.

[c] Calculated from original values given in marks, 1 mark being considered equivalent to 23.8 cents.

[d] Not available.

[e] Allotment for 1918.

Prior to the war Germany consumed about one-half of the potash produced by the German and Alsatian mines, the United States about one-fourth, and European countries nearly all the remainder. During the war Germany used a much larger proportion of the output, while the United States, France, England, Italy, and non-European countries used practically none. The following table shows the distribution of sales of potash by countries from the German and Alsatian mines from 1909 to 1917. The figures for the years 1909 to 1913 represent the total sales; those for the years 1914 to 1917 represent sales for fertilizers only. As about 10 per cent of the output is used in chemical industries, the figures for 1914–1917 should be increased by about 10 per cent to make them comparable with the figures for the earlier years.

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Potash (K_2O) sold from the German mines, by countries, 1909–1917, in metric tons.[a]

Country.	1909	1910	1911	1912	1913	1914	1915	1916	1917
Europe:									
Germany	359,241	418,744	479,839	528,565	604,283	483,627	520,211	680,561	834,382
Belgium	12,642	10,487	10,887	13,028	15,234	10,371	10,764	10,609	14,434
Holland	23,025	29,526	34,583	39,656	43,674	41,990	29,065	56,850	43,841
France	24,431	30,891	34,101	40,092	42,437	19,388	59	1	1
United Kingdom	22,872	24,727	26,784	30,017	29,419	11,629	.....	.....	.....
Austria-Hungary	17,457	16,046	20,257	25,927	28,301	24,195	19,497	28,486	32,492
Italy	5,648	6,375	7,020	8,649	7,320	4,436	474	.....	.....
Scandinavia and Denmark	23,267	25,717	28,626	33,699	34,134	36,503	34,027	43,280	27,760
Russia and Baltic Provinces	10,298	15,982	18,895	25,320	24,568	16,702	1,477	3,659	997
Spain	5,188	7,410	9,914	9,071	8,355	3,184	229	.....	.....
Other countries	3,802	3,898	4,445	5,437	5,319	4,914	4,070	8,506	6,900
	507,871	589,803	675,351	759,461	843,044	656,939	619,873	831,952	960,807
North America, including Hawaii	161,062	258,386	251,859	233,087	248,295	154,434	5,046	.....	.....
Central America	121	168	257	352	370	4,290	23	.....	.....
South America	832	1,195	1,909	2,686	2,549	2,549	692	.....	.....
Africa	962	1,643	2,293	3,141	4,370	1,932	110	.....	.....
Asia, including East Indies	3,029	4,862	6,410	7,836	9,194	4,212	643	35	36
Australia	1,454	1,826	1,848	2,656	2,547	1,652	.....	.....	.....
Grand total	675,331	857,883	939,927	1,009,219	1,110,369	826,008	626,387	831,987	960,843

[a] Figures for 1909–1913 are taken from Federal Trade Commission report on the fertilizer industry, p. 107. Those for 1914–1917 are taken from Wohltmann F., op. cit. p. 32, and include potash for fertilizer use only, and should be increased about 10 per cent to make them comparable with figures for other years.

ALSACE.[1]

Potash salts were discovered at Wittelsheim, 6 miles northwest of Mulhouse, in upper Alsace, in 1904, in drilling for oil. Subsequent explorations and developments indicate that the deposits underlie an area of more than 70 square miles, and that the workable beds have a depth of about 2,000 feet and range in thickness from 6 to 30 feet. The salts consist essentially of sylvinite, a mixture of sylvite and rock salt. Practically no carnallite or magnesium chloride is present. Estimates place the quantity of potash salts in the deposit at 1,472,058,000 metric tons, which on a basis of 22 per cent of potash (K_2O) gives more than 300,000,000 tons of potash (K_2O). The first mining shaft was completed in 1909 and production began in 1910. In 1913 40,707 tons of potash (K_2O) was produced from this source. The German Kali Syndicate, which controlled these mines as well as those at Stassfurt, determined the proportion of potash to be produced by the Alsatian mines at about 4 per cent of the total annual production from Germany. The main object in limiting the output was to prevent overproduction and thus a lowering of the price.

When the armistice was signed in November, 1918, the Alsatian mines were transferred to French control and apparently were in a very bad state of repair. A summary of the preliminary report on

[1] Förster, B., Ergebnisse der Untersuchung von Bohrproben im Tertiär Oberelsass: Geol. Landesanstalt Elsass-Lothringen Mitt., vol. 7, No. 4, 1911. Binder, Félix (and others). Mines de potasse dans la Haute-Alsace: Soc. Ind. Mulhouse Bull., vol. 32, No. 4, pp. 207–300, April, 1912. Wehrlin, A. (chairman of commission). Die Kalibergwerke in Oberelsass: Jahresb. der Ind. Ges. von Muelhausen, Stuttgart, 1913. The world's supply of potash, London, Imperial Institute of the United Kingdom, 1915. Kestner, Paul, The Alsace potash deposits: Soc. Chem. Industry Jour., London, Nov. 15, 1918, pp. 291T–299T.

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the Alsace potash fields prepared in April, 1919, by H. S. Gale, of the United States Geological Survey, who visited the mines early in 1919, is as follows:

1. Seven mines are in operation.
2. Several other mines are being put into operating condition.
3. Able technical talent has been obtained and excellent progress made in rehabilitating the properties.
4. The mines compare fairly well in size and equipment with the best German mines.
5. The daily production is about 2,300 tons of potash salts, averaging about 20 per cent of potash (K_2O), or 460 tons, corresponding to about 150,000 tons of (K_2O) per year.
6. Stocks on hand amount to 62,500 tons of low-grade salts containing nearly 8,000 tons of actual potash (K_2O).
7. February quotations for domestic consumption, delivered at Rotterdam, were about 60 cents per unit of potash (20 pounds of K_2O).
8. Export prices have not been established.
9. Shipping cost from Mulhouse to Rotterdam is about $2.50 per ton.

SPAIN.

Potash deposits were discovered a few years ago in the Province of Barcelona, Spain, near the villages of Suria and Cardona. The salts occur in Oligocene (Tertiary) formations. They consist of irregular beds of carnallite and sylvinite interbedded with and occurring in rock salt. Explorations to a depth of several hundred feet show that in the Suria district potash beds occupy an area of not less than 75 acres and occur at depths from 125 to 200 feet. The average combined thickness of the carnallite beds is estimated to be about 56 feet, and of the sylvinite about 13 feet. The Cardona deposits occur in the axis of a sharp anticline about 220 yards from Cardona. The upper beds are interbedded with gypsum and clay, but the lower beds contain nearly pure white salt, which is that principally mined. After the discovery of potash at Suria, these Cordona beds were searched for potash, and nearly pure sylvite was found. Estimates for the area prospected place the quantity of carnallite at 2,550,000 tons and of sylvinite at 1,150,000 tons.

No production has been reported from this source, but explorations and development are in progress.

GALICIA.

The potash deposits near Kalusz, Galicia, occur at four different horizons in lenticular beds, which attain a thickness of 20 feet and are interbedded with rock salt and saline clay. They contain kainite and sylvinite with relatively small quantities of carnallite and yield an average of about 10 per cent of potash (K_2O). The explored portion of the uppermost bed is estimated to contain more than 100,000 tons of potash salts. The present production is about 1,000 tons of potash (K_2O) annually, which is not sufficient to supply the Galician demands.

CHILE.

The caliche of the Chilean nitrate fields contains from a trace to more than 17 per cent of potassium nitrate. Probably the average is about 2 or 3 per cent. The Du Pont Nitrate Co.[1] began the pro-

[1] Barton, C. M., Met. and Chem. Eng., vol. 18, p. 248, 1918.

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duction of potassium nitrate from the caliche as a by-product in the manufacture of sodium nitrate in 1914 and now has an annual productive capacity of 10,000 tons of a 25 per cent potassium nitrate, representing nearly 1,200 tons of potash (K_2O). The process consists in evaporating the mother liquors from the crystallizing pans to a high density and then cooling the concentrated brine, thus causing a product containing about 25 per cent potassium nitrate to be deposited. The details of this process have been given by the Du Pont Nitrate Co. to other Chilean nitrate producers. The Du Pont Co. produces only about 1 per cent of the total output of the sodium nitrate from the Chilean fields. Potash recovery by all the nitrate-producing companies would result in an estimated annual saving of 120,000 tons of potash (K_2O). Projected improvements in the process may recover practically all the potash from the caliche, which would represent a total estimated output of 320,000 tons of potash (K_2O) for the nitrate industry.

ITALY.

Extensive deposits of alunite occur near Tolfa, Italy, and are utilized in the production of potash salts. Estimates in 1908 placed the ore available at 150,000 to 200,000 metric tons. The quantity[1] of alunite utilized was 3,700 metric tons in 1914 and 4,850 metric tons in 1915.

OTHER COUNTRIES.

So far as known the potash resources of other countries are limited and have yielded only small quantities of potash. They were described in the report for 1917, and the descriptions will not be repeated here, as little or no developments are on record for 1918.

POTASSIUM (METAL).

Metallic potassium (K), a soft white metal, is obtained commercially by electrolyzing fused potassium chloride or potassium hydroxide. It is a powerful reducing agent and has been employed in the preparation of boron, silicon, and various organic compounds and in the analysis of gases. There is, however, no great demand for metallic potassium, as the cheaper sodium is equally applicable for almost all purposes.

No data on domestic production are available, and presumably little or none has been made. Imports in 1914 amounted to 998 pounds, valued at $330, or about 33 cents a pound.

POTASSIUM ACETATE.

Potassium acetate ($KC_2H_3O_2$), which is a deliquescent salt occurring in some vegetable secretions, is obtained commercially by the action of acetic acid on caustic potash or potassium carbonate and also by decomposing lead acetate with potassium carbonate. The commercial salt is liable to contain sulphates, chlorides, carbonates, and heavy metals, and is sometimes intentionally adulterated with

[1] Rivista del Servizio minerario, 1915, p. 182.

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calcium acetate or other ingredients. It is used in bleaching and dye works, in medicine, and in preparing tincture of ferric acetate. Five companies produced 93,307 pounds of 98 to 99 per cent potassium acetate in 1918. The sales amounted to 90,229 pounds, valued at $59,314. Domestic production in other years is not known. Data on imports and exports in 1918 are not available. Imports for the fiscal year ending June 30, 1914, were 528 pounds, valued at $108, or about 20 cents a pound.

The following companies reported production of potassium acetate in 1918:

Albany Chemical Co., Albany, N. Y.
Mallinckrodt Chemical Works, St. Louis, Mo.
Powers-Weightman-Rosengarten Co., Philadelphia, Pa.
Smith, Klein & French Co., Philadelphia, Pa.
E. R. Squibb & Sons, New York, N. Y.

POTASSIUM ALUMINUM SULPHATE (POTASH ALUM).

Potash alum, hydrous potassium-aluminum sulphate ($K_2SO_4Al_2(SO_4)_3.24H_2O$), occurs as an efflorescence or incrustation in many parts of the world, particularly in volcanic regions and where pyritic shales and similar materials are undergoing decomposition. It is very soluble in hot water, rather sparingly soluble in cold water, crystallizes well, and is easily prepared in the pure state.

The main uses of potash alum are in dyeing, in the manufacture of lake pigments, in dressing skins, in fireproofing, in sizing paper, in water purification, in the preparation of other aluminum salts, and in medicine. Being more economical, aluminum sulphate and soda alum are gradually replacing it in most of its applications. These materials do not crystallize well, however, and are difficult to prepare pure, whereas many operations, especially in dyeing, require a material free from iron and other impurities. Hence, the superiority of potash over these substitutes.

From time to time small quantities of the natural alum from Italy, Nevada, and other localities have been purified and marketed. Considerable quantities are produced annually from alunite in Italy and Utah. The process employed in Italy consists in roasting the ore at about 500° C., digesting the residue with water or sulphuric acid, and finally crystallizing the alum. A more modern process consists in calcining the alunite at a higher temperature, digesting the residue with sulphuric acid, adding the requisite amount of potassium chloride, and crystallizing the alum. Alum is still manufactured to a small extent, particularly in England, by digesting with water or roasting finely ground pyritic aluminous shale, lixiviating with water, and crystallizing the product. Sulphuric acid and potassium sulphate may be added to increase the yield. The bulk of potash alum, however, is made in normal times by combining in proper proportions solutions of aluminum sulphate and potassium sulphate and crystallizing the product.

Burnt alum, anhydrous potassium-aluminum sulphate ($K_2SO_4.Al_2(SO_4)_3$), is obtained as a porous mass slowly soluble in water by roasting ordinary alum at a temperature above 100° C.

From 1912 until the war began in 1914 market quotations on lump potash alum ranged from about 1¾ to 2 cents a pound. The price

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rose to 5 cents a pound in 1915, to 8 cents in 1917, and to 12 cents in October, 1918. The domestic output in 1918 sold for about 2½ cents a pound according to reports submitted to the Geological Survey.

The domestic production in 1918 of potash alum and burnt alum of various grades amounted to 10,922,955 pounds, and the sales were only a little less, amounting to 9,699,645 pounds, valued at $251,181. A summary of the production of potash alum and burnt alum in the United States is shown in the following table:

Potash and burnt alum produced in the United States, 1899–1918.[a]

	1899		1904		1909		1914		1918[b]	
	Quantity (pounds).	Value.	Quantity (pounds).	Value.	Quantity (pounds).	Value.	Quantity (pounds).	Value.	Quantity (pounds).	Value.
Potash alum	14,200,000	$215,004	10,307,000	$156,448	10,254,000	$155,319	12,765,000	$219,968	.....	.....
Burnt alum.	6,629,000	174,600	15,858,000	364,328	11,746,000	209,904	22,629,000	364,656	.....	.....
	20,829,000	389,604	26,165,000	520,776	22,000,000	365,223	35,394,000	584,624	9,699,645	$251,181

[a] Data except for 1918 taken from Census of manufactures, chemicals, and allied industries, 1914, U. S. Dept. Commerce Bur. Census.
[b] Sales.

The annual importation of potash alum is known to be small, although no figures are available except for the fiscal year ending June 30, 1914, when 270,114 pounds, valued at $3,493, came into the country. England furnished a large part of this importation and Belgium the remainder.

Reports of production of potassium aluminum sulphate in 1918 were received from the following companies:

American Smelting & Refining Co., Murray, Utah.
E. I. du Pont de Nemours & Co., Wilmington, Del.
Superior Chemical Co., Joliet, Ill.

POTASSIUM BICARBONATE.

Potassium bicarbonate ($KHCO_3$) crystallizes well and is corparatively easy to purify. The saturated solution loses carbon dioxide on boiling, and the solid salt is completely decomposed at 190° C., with the resulting formation of the normal carbonate. It is used in the manufacture of pure potassium carbonate, as a chemical reagent, and in other ways. It may be prepared in several ways, but it is usually obtained commercially by saturating a strong solution of the normal carbonate with carbon dioxide gas and crystallizing the product.

Market quotations before the war ranged around 5 cents a pound; in 1915 the price was from 30 to 50 cents; in 1916, from 50 cents to $1.46, and in 1917 and 1918, from $1.25 to $1.50.

Only one firm, the Mallinckrodt Chemical Co., St. Louis, Mo., reported production in 1918, and the figures are included with those of potassium carbonate (p. 389). The product was about 99 per cent pure. Import figures for the years 1913 to 1918 are shown on pages 391–392. For the fiscal year ending June 30, 1914, the imports were 478,903 pounds, valued at $22,783, of which 88 per cent came from England and the remainder from Germany and Austria.

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POTASSIUM BICHROMATE.

Potassium bichromate ($K_2Cr_2O_7$) is one of the most useful of the chromium salts. It is a powerful oxidizing agent, is stable under ordinary conditions, and finds wide application in chemical industries. Its principal uses are in the manufacture of chrome-yellow and other inorganic pigments and of other chromium compounds, in the manufacture of dyes and other organic compounds, in pyrotechnics, in tanning, in dyeing, in calico printing, in making blue-print paper, in electro-engraving of copper plates, in the autotype and other similar photographic printing processes, in photography, as an oxidizing agent, and as a chemical reagent. In recent years its use has been very largely reduced and its place taken by the cheaper sodium bichromate. Potassium bichromate is prepared by heating to a sintering temperature finely powdered chromite, potassium carbonate, and lime in an oxidizing atmosphere, lixiviating with water, adding potassium sulphate, slightly acidifying with sulphuric acid, and finally crystallizing out the potassium bichromate thus formed. It is also obtained by treating solutions of sodium bichromate with potassium chloride. The salt crystallizes well, making purification easy.

Market quotations of potassium bichromate before the war (1912–1914) were about 7 cents a pound. They rose to 75 cents a pound early in 1916 and then declined, ranging from 39 to 48 cents in 1918.

The figures of production for 1918 have been combined with those of potassium chromate. The total output of these two salts, which were of 98 per cent or higher grade and which consisted chiefly of bichromate, was 681,346 pounds, and the sales, including those of reserve stocks, were 1,003,598 pounds, valued at $407,793. Data for other years are not available, but it is known that for many years domestic producers have largely supplied the consumption. Import figures for 1913 to 1918 are shown on pages 391–392. Imports of bichromate, which came from Austria and Germany, for the fiscal year ending June 30, 1914, were 30,088 pounds, valued at $2,362.

The three firms that reported production of potassium bichromate to the United States Geological Survey for 1918 were as follows:

Michel-Bilodeau Chemical Co. (Inc.), San Francisco, Calif.
Mutual Chemical Co. of America, Jersey City, N. J.
Natural Products Refining Co., Jersey City, N. J.

POTASSIUM BINOXALATE.

(See Potassium oxalate.)

POTASSIUM BISULPHATE.

Potassium bisulphate ($KHSO_4$) occurs native in volcanic regions, notably near Naples, Italy. It is obtained by the action of sulphuric acid on potassium chloride or nitrate and is an intermediate product in the production of potassium carbonate by the Le Blanc process.

The Mallinckrodt Chemical Co. is the only firm that reported production in 1918, and the figures are included with "all others" in the table on page 389. No data are available on production in other years or on imports, except that in 1914 imports valued at less than $100 came into the country.

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POTASSIUM BISULPHITE.

(See Potassium sulphites.)

POTASSIUM BITARTRATE.

(See Potassium tartrates.)

POTASSIUM BROMIDE.

Potassium bromide (KBr) is formed along with bromate when bromine is dissolved in caustic potash, and on evaporation and gentle ignition, preferably in the presence of carbon, the bromate is decomposed with the formation of bromide. It is usually prepared, however, on a large scale by decomposing ferrous bromide, obtained by the action of bromine and water on iron filings, with potassium carbonate, and is purified by recrystallization. Impurities which often contaminate the commercial article are potassium chloride, iodide, and carbonate. Potassium bromide serves as a valuable medicine, especially in cases of nervous diseases, and is used extensively for pharmaceutical purposes, in photography, and as a chemical agent.

Market quotations in 1914 before the war were about 40 cents a pound; this advanced to more than $5 a pound early in 1916. They then declined and ranged from $1.25 to $1.46 a pound in 1918. The domestic output in 1918 sold at an average of a little less than 90 cents a pound.

Domestic production in 1918, as reported to the United States Geological Survey, amounted to 666,119 pounds of United States Pharmacopoeia grade, and the sales amounted to 616,232 pounds, valued at $551,079. Data on production for other years, on imports, and on exports are not available, except that for the fiscal year ending June 30, 1914, 361 pounds were imported, valued at $200.

The following three firms reported production of potassium bromide in 1918:

J. Q. Dickinson & Co., Malden, W. Va.
The Dow Chemical Co., Midland, Mich.
The Heyden Chemical Works, Garfield, N. J.

POTASSIUM CARBONATE.

Potassium carbonate (K_2CO_3) is extremely hygroscopic, is very soluble in water, and crystallizes with difficulty. It possesses a strong alkaline reaction and a caustic taste.

Potassium carbonate is used largely in the manufacture of Bohemian and flint glass, soft soap, potassium hydroxide, acetate, iodide, bromide, bichromate, permanganate, ferrocyanide, silicate, in wool washing, and in bleach and dye works.

It was originally produced solely by lixiviating the ashes of wood and plants and evaporating the lye thus obtained in pots—hence the name potash. Considerable quantities were produced in America and Russia from this source during the European war, the Russian product coming principally from sunflower ash. The crude product, known as crude first sorts, contains a considerable proportion of sulphate and other impurities, and if lime is used in the

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process caustic potash will replace more or less of the carbonate. It is often partly refined to produce a salt containing about 90 per cent of potassium carbonate. One method of refining is by calcining with sawdust, lixiviating with water, allowing the solution to stand in order to separate sulphate and other impurities, and evaporating the clear solution to produce a white salt known as pearl ash.

Although potassium carbonate may be prepared in many ways the bulk of it in normal times is manufactured either by the magnesia-potash process or the Le Blanc process. The magnesia-potash process, which is used extensively in Germany and which has largely replaced other methods, depends on the decomposition of potassium chloride by carbon dioxide in a suspension of magnesium carbonate below 24° C. with the formation of the sparingly soluble compound $KHCO_3.MgCO_3.4H_2O$, which is in turn transformed into potassium carbonate and magnesium carbonate by treatment with hot water or magnesium hydroxide. In the Le Blanc process, which is used largely in the manufacture of soda ash, potassium sulphate, coal, and limestone are calcined to produce a product technically known as "black ash," which contains potassium carbonate, calcium sulphide, unburned coal, unaltered potassium sulphate, etc. On lixiviating the "black ash" potassium carbonate goes into solution along with the various impurities. As potassium carbonate is exceedingly soluble much of the potassium sulphate, ferrocyanide, and other impurities are removed by allowing the concentrated solution to stand. The product finally evaporated contains from 80 to 90 per cent of K_2CO_3 and is frequently refined by re-solution, evaporation and calcining to a product containing from 92 to 98 per cent of K_2CO_3.

A very pure hydrated potassium carbonate free from sulphates and containing 12 to 18 per cent of water is manufactured for certain purposes, particularly for making optical glass. One method is to dissolve ordinary carbonate in water and allow the concentrated liquor to cool and settle, which causes nearly all the sulphate and other impurities to separate. The clear liquor is then evaporated in flat pans to a thick paste, the fire is drawn, and the mass is stirred until it is converted into a coarse powder. The composition of the product approaches the formula $K_2CO_3.2H_2O$.

Chemically pure potassium carbonate, which was formerly obtained by igniting pure potassium bitartrate, is now prepared by calcining pure potassium bicarbonate.

Market quotations from 1912 to 1914, before the war, on 80 to 85 per cent calcined carbonate ranged from 3 to 4 cents a pound. The price advanced to about 90 cents in 1916 and then declined, ranging from 30 to 60 cents a pound in 1918. Quotations on 80 to 85 per cent hydrated potassium carbonate ranged around 3¾ to 4½ cents a pound from 1912 to 1914, advanced to $1.15 a pound in 1916, and varied from about 80 cents to $1.25 in 1918. At the same time quotations on 96 to 98 per cent calcined potassium carbonate ranged from 4¼ to 4¾ cents a pound from 1912 to 1914, advanced to $1.10 in 1916, and ranged from 50 to 80 cents in 1918. The average selling price of the domestic output of crude carbonate from wood ashes in 1918 was a little less than 19 cents a pound and the selling price of the domestic output of refined hydrated carbonate ranged from 40 to 75 cents a pound.

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In 1914 the domestic output of unrefined and refined carbonate was valued at $19,007.

The total domestic output of crude carbonate from wood ashes in 1918 was 1,827,000 pounds, compared with a production in 1914 valued at $30,644. A list of producers is shown on pages 413–414.

The production of refined carbonate in 1918 was reported by three companies, and the figures have been combined with those of bicarbonate, as shown in the table on page 389. The combined output of the two salts amounted to 229,287 pounds. The refined product was hydrated and was about 99 per cent pure.

The three producers of refined carbonate in 1918 were:

Armour Fertilizer Co., Chicago, Ill.
Powers-Weightman-Rosengarten Co., Philadelphia, Pa.
Western Alkali Refining Co., Omaha, Nebr.

Imports of crude carbonate were almost as large in 1918 as in 1914, amounting to 8,594,000 pounds, valued at $2,273,202. They were much less in 1915 and 1917, and they amounted to only 682,000 pounds in 1916. At the same time only 208,000 pounds of refined carbonate, valued at $65,974, came into the United States in 1918, compared with 6,742,000 pounds, valued at $224,384, in 1914. Figures of imports for the years 1913 to 1918 are shown on pages 391–392, and more detailed figures for 1914 on page 396.

Exports of potassium carbonate in 1914 were valued at $1,934. No data for exports are available for other years.

POTASSIUM CHLORATE.

Potassium chlorate ($KClO_3$) is an anhydrous nonhygroscopic salt, which is stable at ordinary temperatures. It is a powerful oxidizing agent and finds wide application in chemical industries. Its more important uses are in matches, primers, percussion caps, detonators, blasting powder, pyrotechnics, magnesium flash-light powders, calico printing and dyeing, welding, paints, pharmaceutical preparations, tooth paste, medicine, the manufacture of dyes and other organic compounds, making oxygen in chemical laboratories, and as an oxidizing and chemical reagent. Formerly potassium chlorate was prepared commercially by passing chlorine gas into milk of lime and converting the calcium chlorate thus formed into the potassium salt by treatment with potassium chloride. The modern method consists in electrolyzing a strong solution of potassium chloride at about 50° C. in such a way that the chlorine and potassium hydroxide formed are brought into contact and allowed to react and in crystallizing the potassium chlorate which is formed.

Market quotations ranged from 7 to 10 cents a pound before the war in 1914, advanced to 50 cents in 1915, reached 75 cents in 1916, ranged from 75 to 40 cents in 1917, and from 45 to 28 cents in 1918. The unusual demand for potassium chlorate and the keen competition for the limited supply of potassium chloride used in its manufacture were leading factors affecting the price.

Domestic production and sales in 1918, as reported to the United States Geological Survey, amounted to 9,753,424 pounds, valued at $2,837,892, or about 29 cents a pound. The product was practically

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pure, containing from 99.8 to 100 per cent $KClO_3$. Data for other years are not available.

During 1918, 710,000 pounds, valued at $248,160, were imported and 1,392,000 pounds, valued at $534,491, were exported. Data for 1914 show 26,000 pounds of imports, valued at $2,235, and do not show exports. Imports have been very irregular, amounting to more than 1,000,000 pounds in 1913 and 1918 and to only 10,000 pounds in 1916. The available data on imports and exports are summarized on pages 390–397.

Firms reporting production of potassium chlorate in 1918 were:

National Electrolytic Co., Niagara Falls, N. Y.
North American Chemical Co., Bay City, Mich.
Ohio Salt Co., Rittman, Ohio.

POTASSIUM CHLORIDE.

Potassium chloride (KCl) is produced in large quantities in Germany and Alsace from carnallite and sylvinite, and during the war considerable quantities were produced in the United States from brine, kelp, cement dust, silicate rock, and wool washings. It is one of the principal fertilizer salts as well as a raw material in the production of many other potassium compounds, notably potassium bromide, bromate, carbonate, chlorate, hydroxide, iodide, iodate, nitrate, and perchlorate. According to the Federal Trade Commission,[1] nearly 10 per cent of the potassium chloride imported before the war was used for chemical purposes. Little information is at hand to show the proportion of the domestic output used in fertilizers and in chemical industries, but it is believed that most of the high-grade product was used in chemical industries.

The total domestic output in 1918 of grades containing 60 per cent or more of KCl was 62,972,000 pounds, containing 41,741,300 pounds of pure KCl. Of this quantity 9,458,000 pounds contained from 92 to 98 per cent of KCl, 4,238,000 pounds contained from 76 to 80 per cent of KCl, and 49,276,000 pounds contained from 60 to 71 per cent of KCl. Statistics of imports are presented in the tables on pages 391, 393, and 396, exports are shown on page 397, and prices are discussed on pages 397–399.

The following firms reported production in 1918:

American Trona Corp., Trona, Calif.
Atlantic Potash Co., Stockertown, Pa.
Calco Chemical Co., 136 Liberty Street, New York, N. Y.
Coplay Portland Cement Co., Coplay, Pa.
Diamond Match Co., 111 Broadway, New York, N. Y.
Hercules Powder Co., Wilmington, Del.
Ogden Portland Cement Co., Ogden, Utah.
Oliver Chemical Co., Mount Eden, Calif.
Salt Lake Chemical Co., Salt Lake, Utah.
Solvay Process Co., Syracuse, N. Y.

POTASSIUM CHROMATE.

Potassium chromate (K_2CrO_4) is prepared by adding the requisite proportion of potassium carbonate or hydroxide to a solution of potassium bichromate. On evaporation potassium chromate is ob-

[1] Report on the fertilizer industry, p. 115, 1916.

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tained in beautiful yellow crystals. It is used largely in the tanning industry. The price in 1918 was between 50 and 60 cents a pound.

Figures of production and importation are combined with those of potassium bichromate, as shown on pages 389, 391, 392, and no data on exports are available. Only one firm, the Mallinckrodt Chemical Co., St. Louis, Mo., reported production of this commodity in 1918, the product consisting of 98 per cent K_2CrO_4.

POTASSIUM CHROMIUM SULPHATE.

Potassium chromium sulphate, chrome alum ($K_2SO_4Cr_2(SO_4)_3 \cdot 24H_2O$), is obtained by passing sulphur dioxide through a solution of potassium bichromate to which the requisite quantity of sulphuric acid has been added. It is now obtained commercially in large quantity as a by-product in the manufacture of alizarin from anthracene. It is used in dyeing, calico printing, and tanning.

Market quotations in 1917 and 1918 were 20 to 23 cents a pound.

No production of chrome alum in the United States has been reported and no data on imports are available, except for the fiscal year ending June 30, 1914, when 842,200 pounds came into the country, valued at $31,384, or about 3.7 cents a pound.

POTASSIUM CITRATE.

Potassium citrate ($K_3C_6H_5O_7 \cdot H_2O$) may be prepared by adding an equivalent quantity of potassium carbonate to a solution of citric acid and evaporating the solution to dryness. It is used extensively in medicine and is an efficient refrigerant, diaphoretic, and diuretic in acute febrile attacks.

Market quotations ranged around 70 cents a pound during the latter part of 1914 and during 1915, advanced to $1.70 a pound early in 1916, and fluctuated around $1.60 to $1.70 a pound during 1918.

Domestic production in 1918 as reported by six firms consisted of 98 per cent or higher grades and amounted to 99,193 pounds; the sales were 96,273 pounds, valued at $141,517, or about $1.47 a pound. Statistics for other years and for imports and exports are not available, except that in 1914 imports were valued at less than $100.

The producing firms in 1918 were:

Albany Chemical Co., Albany, N. Y.
Mallinckrodt Chemical Works, St. Louis, Mo.
Chas. Pfizer & Co., New York, N. Y.
Powers-Weightman-Rosengarten Co., Philadelphia, Pa.
E. R. Squibb & Sons, New York, N. Y.

POTASSIUM CYANIDE.

Potassium cyanide is a white crystalline solid, is very soluble in water, and is a deadly poison. Much of the commercial "potassium cyanide" is actually sodium cyanide. Although sodium cyanide has gradually replaced potassium cyanide in the cyanide process of extracting gold and most of its other applications, potassium cyanide still finds applications in electroplating, photography, casehardening

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of iron, the preparation of certain organic compounds, and as an insecticide, especially in fumigating citrous fruit.

Potassium cyanide (KCN) may be obtained in many ways, including the older commercial methods of heating potassium ferrocyanide alone or with potassium carbonate, and the synthetic methods of passing ammonia and potassium vapors over heated carbon, or of fusing calcium cyanamid with potassium carbonate or potassium chloride and carbon. These methods are applicable to the preparation of sodium and potassium cyanides alike.

Market quotations ranged around 20 to 24 cents a pound in 1914, before the war, advanced to $1.20 a pound in 1916, reached $2.50 a pound in 1917, and fluctuated around 60 to 70 cents a pound in 1918. No domestic production was reported for 1918, and figures for other years are not available.

Imports amounted to 24,000 pounds, valued at $10,278, in 1918, compared with 418,000 pounds, valued at $59,278, in 1914. They amounted to 2,649,040 pounds, valued at $394,141, in 1911; to 726,659 pounds, valued at $109,434, in 1912; and to 1,470,987 pounds, valued at $216,844, in 1913. Data for 1914 to 1918 are shown on pages 391–392. Prior to the war imports came principally from Germany; in 1918 they came largely from Spain and Japan.

POTASSIUM FERRICYANIDE.

Potassium ferricyanide ($K_3Fe(CN)_6$), commonly known as red prussiate of potash, is made by passing chlorine gas into a strong solution of potassium ferrocyanide. It is used largely in making blue-print paper and finds some application in photography, in calico printing, and in the production of pigments.

Market quotations ranged from 26 to 33 cents a pound during 1912 and 1913, advanced from 21 to 55 cents a pound in 1914, fluctuated widely in the early part of the war, reached $5 a pound in January, 1916, and ranged from $2.60 to $2.90 a pound during 1918. The average selling price of the domestic output in 1918, which was practically pure, was $1.90 a pound.

Production in 1918 was reported by two firms—Alexander C. Ferguson and Smith, Klein & French, both of Philadelphia, Pa.—and the figures are included under "all others" in the table on page 389 in order not to disclose confidential data. Imports amounted to about 16,000 pounds in 1918, valued at $29,201, and 80,000 pounds in 1914, valued at $14,446, or about 18 cents a pound. Data of imports for 1913 to 1918 are shown on pages 391–392.

POTASSIUM FERROCYANIDE.

Potassium ferrocyanide ($K_4Fe(CN)_6.3H_2O$), commonly known as yellow prussiate of potash, is a yellow crystalline solid, readily soluble in water. On heating it gives off water of crystallization and falls to a white powder. Its main uses are in the manufacture of prussian and other commercial blues, ferricyanide and other cyanogen compounds, in calico printing, in dyeing, and in case-hardening iron. It was formerly obtained by fusing together crude potash, iron filings, and nitrogenous organic matter such as waste

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leather or hides, digesting the melt with hot water, and finally crystallizing the ferrocyanide from the solution. It may also be similarly obtained from potassium sulphocyanide and iron filings, and as a by-product in the manufacture of potassium carbonate by the Le Blanc process. It is now produced, however, largely from the spent iron oxide obtained during the purification of coal gas. The spent oxide, which has absorbed the cyanogen compounds along with other substances from the coal gas, is washed with water and carbon bisulphide to remove soluble salts and sulphur. It is then mixed with lime and digested with hot water, when calcium ferrocyanide goes into solution. This is treated with a strong solution of potassium chloride, which precipitates a sparingly soluble potassium-calcium ferrocyanide, and this is finally decomposed with potassium carbonate with the resulting production of potassium ferrocyanide.

Market quotations in 1914, before the war, were about 13 cents a pound, and in 1918 they ranged from 80 cents to $1.30 a pound. According to reports of producers the domestic output in 1918 sold at an average price of about 67 cents a pound.

Domestic production in 1918 consisted of 99 per cent or better grades and amounted to 457,267 pounds, and the sales were 306,535 pounds, valued at $204,190. The production in 1914 was 3,204,684 pounds, valued at $451,092, and in 1909 it was 3,510,208 pounds, valued at $463,983.

Imports in 1918 amounted to 129,441 pounds, valued at $112,729, compared with 3,044,000 pounds in 1914, valued at $334,592. About one-half the imports in 1914 came from Germany, one-fourth from England, and the remainder from France, Austria, Holland, and Belgium. Other data on imports are shown on pages 391, 392, 396. The quantity of exports are not known.

The producing firms in 1918 were:

Bahlman-Frederich Chemical Co., Cincinnati, Ohio.
Calco Chemical Co., New York, N. Y.
Penman-Littlehales Chemical Co., Syracuse, N. Y.

POTASSIUM HYDROXIDE.

Potassium hydroxide, or caustic potash (KOH), although not a potassium salt, is an important commercial potassium compound and is included here for convenience. It is a white deliquescent solid, very soluble in water, and absorbs carbon dioxide from the air. It is one of the strongest bases known.

The principal use of caustic potash is in the manufacture of soft soap, shaving soap, toilet preparations, laundry preparations, pharmaceutical preparations, potassium chromate, and many other potassium compounds, oxalic acid, indigo and other dyes and organic compounds, disinfectants, greases and lubricants, in wool scouring, and as a reagent in chemical laboratories. By far the largest part of it, probably 80 per cent, is used in soft soaps.

Potassium hydroxide is obtained by treating dilute solutions of potassium carbonate with lime at the boiling temperature. Calcium carbonate settles out and the resulting lye is purified by evaporation and filtration until finally fused KOH is obtained. The modern method of preparing caustic potash, which has largely supplanted

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other methods, consists in the electrolysis of solutions of potassium chloride.

Market quotations on the 90 per cent grade in 1914, before the war, ranged from 4 to 6 cents a pound, in 1916 from 62 cents to $1 a pound, and in 1918 from 67 to 85 cents a pound. The actual selling price of the best grades produced in 1918 ranged around 70 cents a pound, the average selling price having been a little more than 60 cents for all grades above 88 per cent and about 48 cents for 70 to 80 per cent grades.

Domestic production in 1918, as reported to the United States Geological Survey, amounted to 1,984,847 pounds, and consisted of 1,108,438 pounds, containing 88 per cent or more of KOH, 671,245 pounds containing 70 to 80 per cent of KOH, and 205,164 pounds of solution containing 20 to 45 per cent of KOH. Nearly all the higher-grade product was reported as containing from 88 to 92 per cent of KOH, and nearly all the lower-grade product as a solution containing 45 per cent of KOH. The data of production for 1918, including sales, are shown on page 389, and are not available for other years.

No imports in 1918 were reported. If exports, for which there are no available data, are neglected the available supply of caustic potash in 1918 was 1,984,847 pounds. In 1914, 7,284,000 pounds were imported; unfortunately domestic production and export figures for that year are not available. If exports are neglected, the figures show a far greater supply of caustic potash in 1914 than in 1918. Available data on imports are shown on pages 391, 392, 396.

The following 14 firms reported production of caustic potash in 1918:

Abbotsford Soap & Potash Co., Abbotsford, Wis.
C. F. Burgess Laboratories, Madison, Wis.
Eastern Potash Corporation, Jones Point, N. Y.
Alex. C. Ferguson, Philadelphia, Pa.
Great Northern Manufacturing Co., Antigo, Wis.
John Heinzkill, Appleton, Wis.
Isco Chemical Co. (Inc.), Niagara Falls, N. Y.
Michel-Bilodeau Chemical Co. (Inc.), San Francisco, Calif.
Niagara Alkali Co., Niagara Falls, N. Y.
Oshkosh Potash & Chemical Co., Oshkosh, Wis.
Semet-Solvay Co., Syracuse, N. Y.
August Swartz, Pellston, Mich.
Western Alkali Refining Co., Omaha, Nebr.
Wisconsin Potash Co., Shawano, Wis.

POTASSIUM HYPOPHOSPHITE.

Potassium hypophosphite (KH_2PO_2) may be prepared by boiling phosphorus with a solution of potassium hydroxide and also by decomposing calcium hypophosphite with potassium carbonate. It is used in medicine. No domestic production has been reported to the United States Geological Survey, but in 1914, 300 pounds, valued at $130 was imported.

POTASSIUM IODATE.

Potassium iodate (KIO_3) may be obtained by oxidizing potassium iodide by the electric current or in other ways, but is most readily prepared by heating potassium chlorate with iodine. It is used in medicine and as a chemical reagent.

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The Mallinckrodt Chemical Co., St. Louis, Mo., is the only firm that reported a production in 1918, and the figures are combined with those of bromate and perchlorate as shown in the table on page 389. The price was about $3 a pound. During the fiscal year ending June 30, 1914, 62 pounds was imported, valued at $153, or about $2.45 a pound. Statistics for other years are not available.

POTASSIUM IODIDE.

Potassium iodide (KI) is a manufactured product obtained usually by the action of caustic potash on iodine or of potassium carbonate on ferrous iodide. It finds extensive application in medicine, particularly in the treatment of scrofulous and syphilitic diseases, in photography, and as a reagent in chemical laboratories.

In 1918 eight companies produced 521,678 pounds of potassium iodide and sold 481,301 pounds for $1,587,656, corresponding to $3.30 a pound. Imports amounted to 64,000 pounds, valued at $142,324. Exports are not known. Production and export figures for 1914 are not available, and imports amounted to only 270 pounds, valued at $491. These data are too incomplete to give an idea of the relative consumption of potassium iodide in 1914 and 1918. Price quotations ranged from $2.95 to $3.25 a pound in 1914, and from $3.75 to $4 in 1918.

The following companies reported production in 1918:

Albany Chemical Co., Albany, N. Y.
McKesson & Robbins, New York, N. Y.
Mallinckrodt Chemical Co., St. Louis, Mo.
Merck & Co., Rahway, N. J.
Charles Pfizer & Co., New York, N. Y.
Powers-Weightman-Rosengarten Co., Philadelphia, Pa.
Smith, Klein & French Co., Philadelphia, Pa.
E. R. Squibb & Sons, New York, N. Y.

POTASSIUM NITRATE.

Potassium nitrate (KNO_3), better known as saltpeter, is a white crystalline nonhygroscopic solid without water of crystallization. It is much more soluble in hot than in cold water, making purification easy. Its principal uses are in the manufacture of black powder and pyrotechnics, as an oxidizing agent in certain metallurgic and other operations, as a preservative of meats, as a fertilizer, as a chemical reagent, and in medicine to regulate circulation. Black powder is a mixture of potassium nitrate, sulphur, and charcoal, and is used extensively in blasting operations, in base charges for shrapnel shells, in blank-fire charges, in mixtures for small-arms ammunition, in primers and fuses, and as a detonator for smokeless powder charges.[1] Unfortunately the hygroscopic nature of the more economical sodium nitrate precludes its use generally in explosives.

Potassium nitrate is formed in nature through the action of nitrifying bacteria where nitrogenous organic matter is decomposing in the presence of potash. It occurs in many places throughout the world, notably in caves, around native villages in India, Central America, Mexico, and other warm countries, in arid regions in the

[1] See p. 400 for a fuller description of the military uses of black powder.

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United States and elsewhere, and forms several per cent of the caliche of the Chilean nitrate fields. During the Civil War considerable quantities were produced from nitrate earths obtained from caves in the Southern States. A considerable portion of the world's supply still comes from nitrate earths in India and Central America. It should be noted, however, that all known deposits of natural potassium nitrate are very small in extent and represent merely impregnations or incrustations of surface materials. In recent years many specimens of potassium nitrate have come to the United States Geological Survey from such deposits in the United States.

Originally all the potassium nitrate of commerce was obtained from nitrate earths, and the industry is still carried on by natives in India, Central America, and some other countries. In the process, which is very crude and which is carried out by each worker on a very small scale, nitrate earth is scraped up in the vicinity of the works and lixiviated in crude vats or pots, and the lye is finally evaporated. The potassium nitrate crystallizes out and is purified by recrystallization. A more rational procedure of mixing wood ashes with the nitrate earth is sometimes followed. The product shipped contains from 70 to 90 per cent of potassium nitrate. More progressive natives in India form nitrate beds of ashes and refuse organic matter and thus increase their supply of nitrate earth and their yield of potassium nitrate.

In recent years, however, the bulk of potassium nitrate in commerce has been produced from sodium nitrate and potassium chloride. The salts are dissolved in hot water or in a mother liquor from a previous operation, brought together in the proper proportion, and concentrated by evaporation until a large portion of the sodium has separated as sodium chloride. On filtering the solution and allowing it to cool, a large part of the potassium crystallizes out as potassium nitrate. The potassium nitrate is purified by washing or by recrystallization.

In 1914, before the war, market quotations on potassium nitrate were about 5 cents a pound, and in 1918 they were 31 cents. The maximum price recorded during the war was 38 cents.

In 1918 the domestic production of potassium nitrate was 16,250,433 pounds, and the sales were 8,176,382 pounds, valued at $2,206,788. The output was all manufactured from potassium chloride and imported sodium nitrate, except 640,000 pounds obtained by refining crude imported saltpeter, there being no commercial deposits of potassium nitrate in the United States. The product was practically pure, containing more than 99 per cent of KNO_3. In 1914 the domestic production amounted to 29,480,000 pounds, valued at $1,244,051. Statistics for other years are not available.

Imports of potassium nitrate are less than domestic production. In 1918 there were imported 9,344,000 pounds of crude nitrate, valued at $906,549, and 4,000 pounds of refined nitrate, valued at $730, which compares favorably in quantity with imports in 1913, 1916, and 1917; in 1914 imports were much less and in 1915 they were practically negligible. The statistics are summarized on pages 391–392. Practically all the crude material came from India, except during 1917 and 1918, when much of it came from South America. Prior to

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the war nearly two-thirds of the refined nitrate came from Germany and one-third from England; in 1918 practically all the refined nitrate came from England. Data on exports are not available, except for 1914, when they were valued at $23,286, which probably represented less than half a million pounds of potassium nitrate.

The firms which reported production in 1918 were:

Battelle & Renwick, Jersey City, N. J.
Calco Chemical Co., New York, N. Y.
E. I. du Pont de Nemours & Co., Wilmington, Del.
Hercules Powder Co., Wilmington, Del.

POTASSIUM NITRITE.

Potassium nitrite (KNO_2) is formed by heating potassium nitrate with lead or other metals, with caustic potash and a sulphite, and in other ways. It is also obtained industrially by passing sulphur dioxide into a solution of potassium nitrate containing a suspension of lime. It is used in the preparation of azo-dyes and other organic compounds and as a reagent in chemical laboratories. Before the war it sold for about 20 to 30 cents a pound. No production has been reported in the United States and no data are available on imports, except for 1914, when 414 pounds, valued at $124, came into the United States.

POTASSIUM OXALATES.

Potassium oxalate ($K_2C_2O_4.2H_2O$), which was formerly obtained by heating sawdust with potassium carbonate or hydroxide, is now prepared industrially by heating potassium formate obtained by the action of carbon monoxide on caustic potash. It is used in photography, dyeing, and the preparation of other potassium oxalates. Before the war market quotations were 9 to 10 cents a pound, and the domestic output in 1918 sold for about 67 cents a pound. The Mallinckrodt Chemical Co. is the only firm that reported production in 1918, and the figures are included with "all others," on page 389. The product was about 98 per cent pure. Imports in 1914 amounted to 107,349 pounds, valued at $9,172, or about 8.6 cents a pound.

Potassium binoxalate ($KHC_2O_4.2H_2O$), which occurs in nature in rhubarb, sorrel, and other plants, is formed when normal potassium oxalate is treated with half its equivalent of oxalic or other acid, and is obtained commercially as a by-product in the manufacture of oxalic acid from potassium oxalate. It is used in removing ink stains, in scouring metals, in cleansing wood, and in dyeing. Prices before the war ranged round 9 cents a pound. No domestic production has been reported to the United States Geological Survey, although it is believed that one or two firms produced the salt in 1918. Imports in 1914 amounted to 55,732 pounds, valued at $4,033, or about 7.2 cents a pound.

Potassium titanium oxalate is used as a mordant and is manufactured in the United States by the Eastern Chemical Co., Boston, Mass. In 1914, 77,238 pounds was imported, valued at $10,146, or about 13 cents a pound.

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POTASSIUM PERCHLORATE.

Potassium perchlorate ($KClO_4$) may be produced by heating potassium chlorate, when a mixture of the perchlorate and chloride is formed which can be separated by fractional crystallization. A more modern process is by the electrolytic oxidation of potassium chlorate in neutral or acid solution, or, better still, the transformation of the sodium salt thus formed by addition of potassium chloride. The perchlorate has a larger oxidizing capacity than the chlorate, but is more stable. It is used in explosives and in pyrotechnics. Before the war it sold for 9 to 10 cents a pound and in 1918 for 40 to 50 cents.

The Oldbury Electro-Chemical Co., 19 Cedar Street, New York, N. Y., was the only firm that reported production in 1918, and the figures are included with those of bromate and iodate, on page 389. The product contained 99.6 per cent of $KClO_4$. Imports for the fiscal year ending June 30, 1914, amounted to 24,455 pounds, valued at $1,943, or about 8 cents a pound. No other data on production and imports are available.

POTASSIUM PERMANGANATE.

Potassium permanganate ($KMnO_4$) is a powerful oxidizing agent and disinfectant. It finds extensive use in the arts, particularly in the manufacture of saccharine, in bleaching, in dyeing shoe leather, for coloring wood a deep brown, in pharmaceutical and medicinal preparations, in the purification of ammonia and carbon dioxide, as a disinfecting agent, and as an oxidizing and chemical reagent. It is obtained when a solution of potassium manganate is treated with chlorine, ozone, carbon dioxide, or any acid. The modern method of preparing it is to effect the oxidation by means of the electric current. Potassium manganate is obtained by fusing pyrolusite (MnO_2) with caustic potash or potassium carbonate, or by decomposing sodium manganate with potassium chloride.

Market quotations early in 1914 were about 10 cents a pound, and in 1918 they ranged from $4 in January to $1.30 in December and were affected by a shortage in both potash and manganese.

Nine companies reported the production of 562,416 pounds of potassium permanganate of 97 per cent or better grade in 1918, and the sales at 530,837 pounds, valued at $922,746, or about $1.74 a pound. Imports amounted to 54,000 pounds, valued at $128,438, or $2.37 a pound. The quantity of exports is not known. Statistics for other years are not available, except on imports, which are shown in the table on pages 391, 392, 396. Prior to the war the imports came from Germany almost exclusively; in 1918 they came principally from Japan.

The producing companies in 1918 were:

Armour Fertilizer Works, Chicago, Ill.
Carus Chemical Co., La Salle, Ill.
General Supply Co., Perth Amboy, N. J.
Michel-Bilodeau Chemical Co. (Inc.), San Francisco, Calif.
Niagara Alkali Co., Niagara Falls, N. Y.
Pacific Minerals & Chemical Co., Los Angeles, Calif.
Poindexter & Co., Los Angeles, Calif.
Scott & Gilbert Co., San Francisco, Calif.
Secaw Chemical Co., Irvington, N. J.

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POTASSIUM PERSULPHATE.

Potassium persulphate ($K_2S_2O_8$) is obtained by the electrolysis of a saturated solution of potassium bisulphate. It is a powerful oxidizing agent and finds a slight application as such, particularly in photography. In 1914 236 pounds was imported, valued at $920, and in 1918 no domestic production was reported. Statistics for other years are not available.

POTASSIUM PHOSPHATES.

Tribasic potassium phosphate (K_3PO_4) may be prepared by heating a mixture of phosphate rock, coke, and potassium sulphate, lixiviating the residue with water, and evaporating the solution. Dibasic potassium phosphate (K_2HPO_4), the most common phosphate of potassium, is obtained by the action of sulphuric acid and potassium bisulphate on calcium phosphate, or by the action of phosphoric acid on potassium carbonate. Monobasic potassium phosphate (KH_2PO_4), obtained by the action of phosphoric acid on potassium carbonate, is also known. These salts crystallize poorly and have little commercial importance, the corresponding soduim salts being usually preferred.

Both the dibasic and the monobasic salts were produced in the United States in 1918, but as only two firms made reports the figures have been included under " all others " in the table on page 389. The products were about 97 per cent pure. The only available data on imports are those for 1914, which are shown on page 396.

Potassium glycerophosphate ($C_3H_7O_3.PO_3K_2$) is formed by neutralizing glycerophosphoric acid with potassium hydroxide or carbonate or by decomposing the calcium salt with potassium carbonate. It is used in medicine. No production has been reported in the United States, and the imports for the fiscal year ending June 30, 1914, amounted to only 244 pounds, valued at $228.

POTASSIUM SILICATE.

Potassium silicate is formed by dissolving silicic acid in a solution of potassium hydroxide or by fusing silica with potassium carbonate and is obtained commercially by melting together quartz sand, potassium carbonate, and powdered coal, and dissolving the residue in superheated water. It is used in cotton printing, fresco printing, in soap, for fixing colors in stereochrome work, in fireproofing, and in making varnishes, etc., but sodium silicate answers equally well for most purposes. The composition of potassium silicate varies, but usually corresponds approximately to $K_2O.4SiO_2$. No production was reported in the United States in 1918. Other statistics are not available except on imports in 1914, when more than 150,000 pounds of solution came into the country, as shown on page 396.

POTASSIUM SULPHATE.

Potassium sulphate (K_2SO_4) is used largely as a fertilizer, particularly in growing tobacco and citrus fruits, and is also used in the preparation of alum and potassium carbonate, and in medicine. It is manufactured on a large scale in Germany from kainite, and

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also from potassium chloride by treatment with sulphuric acid. Considerable quantities have been produced during the war from alunite in Utah, and small quantities have been produced from other sources. Prices are discussed on pages 397–399. Statistics of production are shown on page 388, and imports on pages 391–392. According to the Federal Trade Commission,[1] about 2 per cent of the potassium sulphate imported before the war was for chemical purposes, 430 metric tons, or 948,000 pounds, having been imported in 1914 for chemical use.

The following companies reported production of potassium sulphate in 1918:

Mineral Products Corp., Marysvale, Utah.
California Portland Cement Co., Colton, Calif.
Newaygo Portland Cement Co., Newaygo, Mich.
Riverside Portland Cement Co., Riverside, Calif.
Santa Cruz Portland Cement Co., Davenport, Calif.
Southwestern Portland Cement Co., Victorville, Calif.
Portland Cement Co. of Utah, Salt Lake City, Utah.
Tennessee Coal, Iron & Railroad Co., Birmingham, Ala.

POTASSIUM SULPHIDES.

Potassium sulphide (K_2S) is usually obtained by heating potassium sulphate with an excess of carbon. On lixiviating the fused mass and concentrating the solution potassium sulphide ($K_2S.5H_2O$) crystallizes in colorless, deliquescent prisms. It is used extensively in photography, in toning prints, and also in dyeing.

Two companies—Mallinckrodt Chemical Works, St. Louis, Mo., and Smith, Kline & French Co., Philadelphia, Pa.—reported production in 1918 and the figures are included with "all others" in the table on page 389. Nearly all the product contained about 50 per cent of K_2S. Prices ranged from about 30 to 90 cents a pound. No data are available on imports, except that in 1914 the value was less than $100.

Potassium hydrogen sulphide is obtained in solution by passing hydrogen sulphide into a solution of potassium hydroxide. Polysulphides (K_2S_3, K_2S_4, K_2S_5) are obtained by boiling solution of K_2S with free sulphur. Liver of sulphur used in medicine is a mixture of K_2S_3, $K_2S_2O_3$, and K_2SO_4 and is obtained by melting a mixture of potassium carbonate and sulphur.

POTASSIUM SULPHITES.

Potassium sulphite (K_2SO_3) is prepared by dissolving 100 grams of caustic potash in 200 cubic centimeters of air-free water, saturating the solution with sulphur dioxide, adding a further quantity of 100 grams of caustic potash dissolved in a little water, and evaporating the solution in vacuo.

It forms two hydrates—$K_2SO_3.H_2O$ and $K_2SO_3.2H_2O$. It is a strong reducing agent, and solutions readily undergo oxidation in the air. The Mallinckrodt Chemical Co. is the only firm that reported production in 1918, and the figures are included with "all others" on page 389. Available data on imports are shown on page 396.

Potassium bisulphite ($KHSO_3$) is produced when a solution of potassium hydroxide is saturated with sulphur dioxide, and is pre-

[1] Report on the fertilizer industry, p. 115, 1916.

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cipitated in needle-shaped crystals by the addition of alcohol. Production in 1918 was reported by only one firm, the Mallinckrodt Chemical Co., St. Louis, Mo., and the figures are included in the item "all others," page 389. The output was about 93 per cent pure and sold at about 52 cents a pound. In 1914, 35,200 pounds of 30 per cent bisulphite liquid, valued at $656, and 185 pounds of crystals, valued at $16, were imported. The value of the crystals corresponds to a little more than 8.6 cents a pound.

Potassium pyrosulphite ($K_2S_2O_5$), known also as metasulphite and metabisulphite, is formed when sulphur dioxide is passed into a hot saturated solution of potassium carbonate and is obtained in crystalline form on cooling the solution. It is employed extensively in photography. No domestic production has been reported to the Geological Survey, but in 1914 considerable quantities were imported listed as metasulphite and metabisulphite, as shown on page 396. The value of the commercial liquid imported was 5 to 6 cents a pound and the value of pure crystals was 12 to 17 cents a pound.

POTASSIUM TARTRATES.

Potassium bitartrate ($KH[C_4H_4O_6]$) is the principal constituent of wine lees, argol, and cream of tartar. Lees is the solid matter collected from the bottom of the vessels in which grape juice is fermented, and argol is the crystalline crust deposited on the sides of the vessels. Lees contain 24 to 32 per cent of tartaric acid and argol 40 to 70 per cent, mostly in the form of potassium bitartrate. Cream of tartar, which consists chiefly of potassium bitartrate, is prepared from argol by recrystallization, and it is often contaminated with starch and other adulterants. Argol is used in assaying, cream of tartar in baking powders, and purified potassium bitartrate in candy, in pharmaceutical preparations, and in the manufacture of tartaric acid and other tartrates. Probably 90 per cent of the bitartrate produced is used in manufacturing baking powder.

Potassium tartrate ($K_2[C_4H_4O_6]$) is obtained by neutralizing potassium hydrogen tartrate with potassium carbonate or hydroxide. It forms colorless crystals freely soluble in water.

Potassium sodium tartrate, or Rochelle salt ($KNa[C_4H_4O_6]$), is obtained by neutralizing potassium bitartrate with sodium carbonate or hydroxide. Its chief use is in medicine, but it now also finds some application in electric intensifiers.

Potassium antimonyl tartrate, or tartar emetic ($KSbO.C_4H_4O_6.H_2O$), is obtained by dissolving antimonious oxide in a solution of potassium bitartrate and crystallizing out the product. It is used in medicine and as a mordant in dyeing.

Statistics of production of tartrates are grouped together and shown on page 389, while data on imports are shown on pages 391, 392, 396. The products were practically pure. The producing firms in 1918 were as follows:

American Cream of Tartar Co., San Francisco, Calif.
Mallinckrodt Chemical Co., St. Louis, Mo.
Chas. Pfizer & Co., New York, N. Y.
Tartar Chemical Works, New York, N. Y.

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POTASSIUM THIOCYANATE.

Potassium thiocyanate (KCNS) is formed by heating potassium cyanide and sulphur or by boiling a mixture of potassium ferrocyanide, potassium carbonate, and sulphur, and in other ways. It is used as a chemical reagent and has been used as a refrigerant, but finds very slight application. No production was reported in 1918, and the available data on imports are shown on page 396.

OTHER POTASSIUM SALTS.

Small quantities of other potassium salts are undoubtedly produced in the United States, but none were reported as having been produced in 1918, and no data for other years are available. A list of such salts imported in 1914 is given on page 397.

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ASPHALT.[1]

By C. C. OSBON.

GENERAL CONDITIONS OF THE ASPHALT INDUSTRY.

Asphalt has long been widely used in making roads, and in recent years many producers of asphalt and related bitumens have succeeded in getting their products extensively employed in the construction of buildings and in other industries. Whether it is used in the manufacture of flooring, roofing, waterproof coating, insulation, mineral rubber, varnish, or paint, asphaltic material has been found satisfactory, and asphalt products are now in great demand among contractors and engineers.

There was a distinct tendency in 1918 toward municipal economy in street paving; many projects involving the construction of new pavement were postponed, and contract work involving asphaltic material was restricted in large measure to the repairing and resurfacing of existing pavements. However, the increased demand for asphaltic material in the construction of highways in the vicinity of military posts, cantonments, and shipyards, in the manufacture of roofing materials for the thousands of temporary and semipermanent buildings that were erected throughout the country in 1918, and for other purposes in war work nearly offset municipal economy, and as a consequence the output of asphalt declined only about 13 per cent.

Although the conditions that existed during the war were adverse to an increase in the output of 1918 over that of 1917, more asphalt was produced in 1918 than in any year preceding the war, and the outlook for the industry is now very encouraging. Restrictions upon the importation of native asphalt and upon the laying of new pavements have been removed. Embargoes on the use of tank cars and coastwise shipping are no longer in effect. The maintenance of many highways throughout the country was neglected during the war; roads were subjected to the strain of unusually heavy motor-truck traffic; plans for new work were held in abeyance; and many an industrial town assumed the proportions of a city. Extensive repairs and new work are therefore immediately necessary, and a large number of contracts have already been awarded.

The conditions in Washington, D. C., which contains more than 350 miles of street pavement and in which asphalt is a popular paving material, are similar to those in many other typical American cities. Plans for street improvement in that city have long been delayed, and it is reported that pavements valued at more than $500,000 were laid in 1919—a new record for Washington.

[1] The statistical tables presented in this report are largely the work of Mrs. Andrena Stratton, Miss A. B. Coons, and J. A. Dorsey.

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According to the Department of Agriculture more roads were constructed by the United States Government in 1919 than in any preceding year. Building operations that involve the use of asphalt products have also been resumed on a large scale throughout the country. In view of these conditions, of the many new uses of asphaltic material, and of the fact that producers of asphalt have recently formed a cooperative association for the general welfare of the industry, it seems that the demand for asphalt and related bitumens will correspondingly increase and that a new record will be established.

Despite the curtailment of the imports of native asphalt and of road and building construction in the United States caused by the war, the year 1918 was one of prosperity for the domestic asphalt industry. Although the output was less than that in 1917, the value exceeded that of any preceding year, and the general prosperity was shared by practically all branches of the industry. The most striking development, however, was the large increase in the value of petroleum asphalt produced from imported Mexican oil.

The statistics presented on subsequent pages indicate that the war adversely affected the importation and production of all varieties of asphalt and related bitumens in the United States in 1918 except Mexican petroleum asphalt, ozokerite, and ichthyol and that it stimulated prices for all asphaltic material produced in this country. The favor with which petroleum asphalt has been received in the United States is indicated by the facts that its production from domestic petroleum nearly doubled in the four years preceding 1918 and that the production of petroleum asphalt from imported oil more than doubled in that period. Despite the fact that conditions were unfavorable for the production of asphalt in 1918 and that asphalt is produced from petroleum of grades suitable for fuel, and despite the large requirements of fuel oil for bunker loading at Atlantic ports and for war industries in or adjacent to the Atlantic seaboard in 1918, the output of petroleum asphalt from Mexican oil increased 1 per cent and the output of petroleum asphalt from domestic oil declined only 25 per cent.

The imports of crude native asphalt declined during the war, but the resumption of normal conditions will probably restore this trade to its pre-war proportions.

The domestic ozokerite industry, revived in 1916 by the American Chemical & Ozokerite Co. and fostered by the discontinuance of imports from Galicia, made substantial progress in 1918.

The total number of companies engaged in the production of asphalt and related bitumens in the United States in 1918 was 42. Thirty-two operators contributed to the output of petroleum asphalt, compared with 40 in 1917. Of the operators in 1918, 21 produced asphalt exclusively from domestic petroleum, 9 exclusively from Mexican petroleum, and 2 from oil of both domestic and Mexican origin. California supplied petroleum of asphaltic base to 14 plants, Illinois to 3, Louisiana and Oklahoma to 2 each, and Kansas, Texas, and Ohio to 1 each. Ten plants contributed to the country's supply of bituminous rock, gilsonite, grahamite, ozokerite, and wurtzilite (known to the trade as elaterite) in 1918 as follows: Utah, 4; California, 3; and Kentucky, Oklahoma, and Texas, 1 each. Bituminous

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sandstone was produced at 4 of these plants, gilsonite at 3, and bituminous limestone, grahamite, ozokerite, and wurtzilite each at 1. One plant produced both gilsonite and wurtzilite.

PRODUCTION.

The quantity of asphalt and related bitumens produced in the United States in 1918 was 1,237,853 short tons, valued at $18,540,032, a decrease of 191,173 tons, or about 13 per cent, in output but an increase of $2,590,104, or a little more than 16 per cent, in value, compared with the production of 1,429,026 tons, valued at $15,949,928, in 1917. The accompanying tables and figure 63 show that the output and value of asphalt and related bitumens have materially increased in recent years.

PETROLEUM ASPHALT.

The output of the petroleum asphalt industry is assigned to two major classes—solid and semisolid products of less than 200 penetration[1] and liquid products of over 200 penetration. The solid and semisolid products include paving asphalt used in the construction of sheet-asphalt pavements, asphaltic concrete, and asphalt blocks; binder used for direct application to gravel, stone, and concrete pavements and for the maintenance of bituminous macadam and bituminous concrete pavements; filler introduced directly into the joints of block, brick, and stone pavements; and other asphalt used in the manufacture of roofing and waterproofing materials, mineral rubber, insulation, acid-resistant compounds, and mastic. The liquid or soft products include road oil used largely for laying dust; paving, roofing, and waterproofing flux used in softening native asphalt and solid petroleum asphalt; and other asphalt used in saturating felts and in the manufacture of paint, japan, and varnish.

The total output of petroleum asphalt in this country in 1918 was 1,177,819 short tons, a loss of 169,603 tons, or about 13 per cent, compared with 1917. The average price received at the refineries for this material was $15.08 a ton and the gross market value was $17,759,224, a gain of $3.82 in average unit price and of $2,582,720, or 17 per cent, in value over 1917. The foregoing totals include 616,547 tons of solid and semisolid products, valued at $10,346,963, an average of $16.78 a ton, and 561,272 tons of liquid products, valued at $7,412,261, an average of $13.21.

The production in 1918 of petroleum asphalt derived from domestic oil amounted to 527,575 short tons, a loss of 174,234 tons, or nearly 25 per cent, of the output in 1917. The average price obtained for this material was $14.09 a ton and the value of the entire output was $7,435,204, a gain of $3.07 in average sale price, but a loss in value of $299,487, or nearly 4 per cent, compared with 1917. Included in the totals of asphalt derived from petroleum of domestic origin are 278,166 short tons of solid and semisolid products utilized mainly in the paving and roofing industries, valued at $4,371,742—an average of $15.72 a ton; and 249,409 tons of liquid products, com-

[1] The "penetration" is the distance, in hundredths of a centimeter, a No. 2 sewing needle will penetrate into the material in five seconds under a weight of 100 grams at a temperature of 77° F.

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prising road oil, flux, and asphaltic paint, valued at $3,063,462—an average of $12.28 a ton. Compared with the price in 1917, the aver-

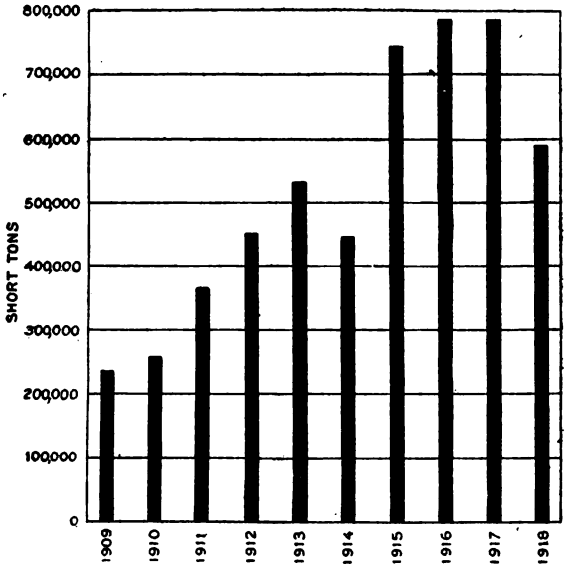

FIGURE 63.—Diagram showing growth of the domestic asphalt industry.

age market price per ton in 1918 of solid and semisolid asphaltic products derived from domestic petroleum was $3.46 higher, and that of the liquid products was $2.34 higher.

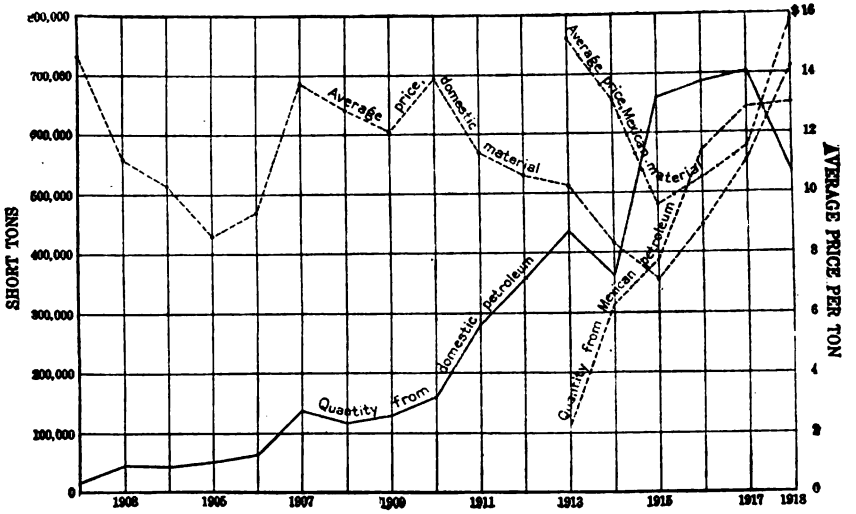

FIGURE 64.—Diagram showing fluctuations in the production and price of petroleum asphalt in the United States, 1902–1918.

The production in 1918 of petroleum asphalt derived from imported Mexican oil amounted to 650,244 short tons—a gain of 4,631 tons, or about 1 per cent, compared with the output in 1917. The

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average price received for the material f. o. b. the refineries was $15.88 a ton, and the gross market value was $10,324,020—a gain of $4.35 in average sale price per ton and of $2,882,207, or nearly 39 per cent, in gross market value compared with 1917.

The gross production of Mexican petroleum asphalt includes 338,381 tons of solid and semisolid products, valued at $5,975,221, an average of $17.66 a ton, and 311,863 tons of liquid products, valued at $4,348,799, an average of $13.94 a ton. Compared with the prices received in 1917 for corresponding products those received in 1918 for the solid and semisolid varieties averaged $3.90 a ton higher and those received for the liquid varieties $4.87 a ton higher.

The accompanying diagrams show graphically the growth of the domestic asphalt industry and the fluctuations in the production and price of petroleum asphalt in the United States.

Asphalt produced from domestic petroleum, 1902–1918.

Year.	Quantity (short) tons).	Value.	Year.	Quantity (short) tons).	Value.	Year.	Quantity (short tons).	Value.
1902	20,826	$303,249	1908	119,817	$1,540,396	1914	360,683	$3,016,969
1903	46,187	522,164	1909	129,594	1,565,427	1915	664,503	4,715,583
1904	44,405	459,135	1910	161,187	2,225,833	1916	688,334	6,178,851
1905	52,369	452,911	1911	277,192	3,173,859	1917	701,809	7,734,691
1906	64,997	615,406	1912	354,344	3,755,506	1918	527,575	7,435,204
1907	137,948	1,898,108	1913	436,586	4,531,657			

Asphalt produced in the United States from Mexican petroleum, 1913–1918.

Year.	Quantity (short tons).	Value.	Year.	Quantity (short tons).	Value.
1913	114,437	$1,743,749	1916	572,387	$6,018,851
1914	313,787	4,131,153	1917	645,613	7,441,813
1915	388,318	3,730,436	1918	650,244	10,324,020

NATIVE ASPHALT AND RELATED BITUMENS.

According to reports received by the Geological Survey the quantity of native asphalt and related bitumens, including bituminous rock, gilsonite, grahamite, ozokerite, and wurtzilite produced from mines and quarries in the United States in 1918 was 60,034 short tons, a quantity less by 21,570 tons, or about 26 per cent, than the output of similar materials in 1917. The average price received for this material at the source of production was $13.01 a ton, and the market value of the entire output was $780,808, a gain of $3.53 a ton in average unit price and of $7,384, or 1 per cent, in gross market value, compared with 1917. At the mines bituminous rock sold in 1918 for an average price of $3.64 a ton, gilsonite for $19.67 a ton, grahamite for $7 a ton, ozokerite for 61 cents a pound, and wurtzilite for $60 a ton. An analysis of statistics of production in 1917 and 1918 shows losses in 1918 in the output of all the native asphalts and related bitumens except ozokerite, which gained more than 100 per cent. The data relating to bituminous rock are incomplete. It is believed that the resumption of normal conditions will

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increase the production of bituminous rock and of gilsonite. Gilsonite is in demand as a base for marine paints and protective coatings for steel work and for use in the manufacture of automobile tires and other rubber products. The decreased output of grahamite and wurtzilite in 1918 was due to the high cost of mining and marketing these minerals and to their inability to compete with certain grades of petroleum asphalt.

Native asphalt and related bitumens produced in the United States, 1882–1918.

Year.	Quantity (short tons).	Value.	Year.	Quantity (short tons).	Value.	Year.	Quantity (short tons).	Value.
1882	3,000	$10,500	1895	68,163	$348,281	1908	78,565	$517,485
1883	3,000	10,500	1896	80,503	577,563	1909	99,061	572,846
1884	3,000	10,500	1897	75,945	664,632	1910	98,393	854,234
1885	3,000	10,500	1898	76,337	675,649	1911	87,074	817,250
1886	3,500	14,000	1899	75,085	553,904	1912	95,166	865,225
1887	4,000	16,000	1900	54,389	415,958	1913	92,604	750,713
1888	50,472	190,500	1901	63,134	555,335	1914	79,888	642,123
1889	51,760	174,037	1902	84,632	461,799	1915	75,751	526,490
1890	41,016	216,666	1903	55,068	483,282	1916	98,477	923,281
1891	45,079	249,264	1904	64,167	420,701	1917	81,604	773,424
1892	87,710	453,375	1905	62,898	305,242	1918	60,034	780,808
1893	47,779	372,232	1906	73,062	674,934			
1894	60,570	353,400	1907	85,913	928,381			

PRODUCTION BY VARIETIES AND BY STATES.

Asphalt and related bitumens produced in the United States, 1913–1918, by varieties.

Variety.	1913		1914		1915	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Petroleum asphalt [a]	436,586	$4,531,657	360,683	$3,016,969	664,503	$4,715,583
Bituminous rock	57,549	173,764	51,071	162,622	44,329	157,083
Gilsonite	35,055	576,949	19,148	405,966	20,559	275,252
Wurtzilite						
Grahamite			9,669	73,535	10,863	94,155
	529,190	5,282,370	440,571	3,659,092	740,254	5,242,073

Variety.	1916		1917		1918	
Petroleum asphalt [a]	688,334	$6,178,851	701,809	$7,734,691	527,575	$7,435,204
Bituminous rock	63,172	197,286	41,919	136,255	25,346	[b] 92,238
Gilsonite	26,870	629,640	[c] 35,049	[c] 532,989	30,848	606,639
Ozokerite	4	3,800	18	1,000	37	45,399
Other bituminous substances	8,431	92,555	[d] 4,618	[d] 103,180	[e] 3,803	[e] 36,532
	786,811	7,102,132	[f] 783,413	[f] 8,508,115	587,609	8,216,012

[a] Includes asphalt produced from domestic petroleum only.
[b] Incomplete.
[c] Includes wurtzilite.
[d] Includes maltha and grahamite.
[e] Includes grahamite and wurtzilite.
[f] Revised figures.

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Asphalt produced in the United States in 1918 from petroleum of domestic and Mexican origin, by months and varieties.

Month.	Solid and semisolid products.					
	Paving asphalt.		Binders and fillers.		Other products.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
January	23,681	$362,153	4,654	$73,426	26,380	$489,928
February	19,164	297,994	3,763	54,402	24,512	434,177
March	22,385	352,554	8,422	117,752	28,994	508,688
April	23,484	360,417	5,804	89,515	23,683	443,464
May	24,413	356,900	9,784	151,067	24,286	478,163
June	23,701	345,706	7,596	108,493	24,524	462,981
July	24,365	348,880	10,724	162,240	26,194	505,351
August	21,367	324,932	7,042	109,858	32,606	616,707
September	17,051	265,269	7,734	120,726	20,900	396,294
October	16,706	238,508	11,042	184,261	21,447	389,107
November	12,191	176,715	3,393	49,054	15,960	314,164
December	16,080	244,356	5,521	81,278	16,994	331,483
	244,588	3,674,384	85,479	1,302,072	286,480	5,370,507

Month.	Liquid products.						Total.	
	Road oil.		Flux.		Other products.			
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
January	5,346	$50,852	20,015	$227,050	5,325	$69,483	85,401	$1,272,892
February	5,919	54,837	17,752	211,355	5,432	97,301	76,542	1,150,066
March	7,666	75,099	33,243	436,597	11,476	174,688	112,186	1,665,378
April	7,684	79,233	25,911	333,623	10,369	162,152	96,935	1,468,404
May	16,109	203,019	35,781	482,140	9,877	153,707	120,250	1,824,996
June	10,749	128,055	34,551	482,822	7,617	123,586	106,738	1,651,643
July	10,365	122,207	31,706	419,130	6,392	111,174	109,746	1,668,982
August	9,971	120,464	28,247	375,233	11,681	179,496	110,914	1,726,690
September	9,525	113,876	34,710	461,703	16,058	235,586	105,978	1,593,454
October	9,530	107,974	31,464	414,435	14,843	219,963	105,032	1,554,248
November	8,964	99,835	29,467	408,723	3,412	70,986	73,387	1,119,477
December	5,503	57,307	26,800	297,238	1,812	51,332	72,710	1,062,994
	107,331	1,212,758	349,647	4,550,049	104,294	1,649,454	1,177,819	17,759,224

Asphalt produced in the United States in 1918 from domestic petroleum, by months and classes of oil used.

Month.	California.		Illinois.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.
January	22,572	$299,913	9,001	$115,850
February	16,579	208,913	6,941	89,733
March	17,228	225,895	9,658	132,027
April	15,121	197,700	9,463	130,273
May	18,896	249,135	10,411	141,865
June	18,375	249,604	8,242	108,984
July	15,194	205,644	9,117	122,307
August	14,414	192,752	8,650	108,076
September	12,635	163,004	7,854	95,310
October	17,202	230,775	6,631	81,054
November	13,846	182,990	7,375	90,671
December	13,213	190,518	7,609	98,851
	195,275	2,596,843	100,952	1,315,001

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Asphalt produced in the United States in 1918 from domestic petroleum, etc.—Con.

Month.	Oklahoma.		Other States.[a]		Total.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
January	4,919	$50,732	9,453	$187,671	45,945	$654,166
February	7,869	85,700	8,549	168,238	39,938	552,584
March	6,662	74,511	12,680	221,488	46,228	653,921
April	8,261	92,657	8,685	162,594	41,530	583,224
May	13,281	157,833	12,441	221,494	55,029	770,327
June	10,332	118,131	12,065	209,168	49,014	685,887
July	11,644	147,407	8,428	151,198	44,383	626,556
August	12,458	162,607	10,257	202,552	45,779	665,987
September	10,314	132,394	11,402	202,946	42,205	593,654
October	12,274	158,485	8,255	147,102	44,362	617,416
November	8,305	105,486	8,455	142,133	37,981	521,280
December	5,913	71,733	8,446	149,100	35,181	510,202
	112,232	1,357,676	119,116	2,165,684	527,575	7,435,204

[a] Includes Kansas, Louisiana, Ohio, and Texas.

Asphalt produced in the United States in 1918 from Mexican petroleum, by months and varieties.

Month.	Solid and semisolid products.					
	Paving asphalt.		Binders and fillers.		Other products.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
January	7,094	$113,173	2,634	$40,297	16,524	$317,683
February	4,502	80,787	3,114	44,197	15,682	288,396
March	7,642	126,362	7,538	104,737	22,063	380,571
April	8,193	133,213	4,838	74,344	16,944	319,412
May	8,201	123,259	7,571	114,564	15,671	326,368
June	5,996	90,528	6,196	86,635	16,900	334,194
July	8,940	128,654	8,420	124,547	19,131	385,123
August	6,642	107,309	5,268	80,229	21,278	418,026
September	6,475	108,524	5,842	90,887	13,678	272,083
October	4,821	72,024	9,623	160,376	11,775	228,883
November	4,102	61,819	2,726	38,249	10,441	218,288
December	7,276	110,201	4,870	70,168	9,772	201,117
	79,884	1,255,853	68,638	1,029,230	189,859	3,690,138

Month.	Liquid products.						Total.	
	Road oil.		Flux.		Other products.			
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
January	198	$2,636	9,793	$102,903	3,213	$42,034	39,456	$618,726
February	354	4,749	9,194	104,740	3,758	74,613	36,604	597,482
March	943	13,590	17,136	222,348	10,636	163,849	65,958	1,011,457
April	2,094	28,294	13,658	175,099	9,678	154,818	55,405	885,180
May	5,593	88,414	18,681	252,707	9,504	149,357	65,221	1,054,669
June	5,179	72,765	18,486	266,220	6,967	115,414	59,724	965,756
July	4,754	60,903	18,302	249,534	5,816	103,685	65,363	1,042,426
August	4,312	60,129	16,665	235,555	10,972	169,461	65,135	1,060,703
September	3,249	47,296	19,106	253,444	15,423	227,586	63,773	999,800
October	1,270	17,861	19,107	248,700	14,074	208,988	60,670	936,832
November	381	5,467	15,194	214,987	2,562	59,387	35,406	598,197
December	174	2,616	14,138	125,923	1,299	42,787	37,529	552,792
	28,501	404,720	189,460	2,432,160	93,902	1,511,919	650,244	10,324,020

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Native asphalt and related bitumens produced in the United States, 1913–1918, by States.

State.	1913		1914		1915	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
California	27,870	$69,825	28,186	$77,810	17,794	$61,485
Oklahoma	16,459	91,416	9,669	73,535	16,907	118,351
Utah	30,810	529,341	23,098	424,480	[a] 21,739	[a] 281,302
Other States [b]	17,465	60,131	18,935	66,298	19,311	65,352
	92,604	750,713	79,888	642,123	75,751	526,490

	1916		1917		1918	
California	18,135	$45,102	6,009	$19,447	3,260	$12,516
Utah	26,874	633,440	35,192	589,325	31,072	663,258
Other States	[c] 53,468	[c] 244,739	[c] 40,403	[c] 184,652	[d] 25,702	[d] 105,034
	98,477	923,281	[e] 81,604	[e] 773,424	60,034	780,808

[a] Includes Colorado.
[b] Includes Kentucky and Texas.
[c] Includes Colorado, Kentucky, Oklahoma, and Texas.
[d] Includes Kentucky, Oklahoma, and Texas.
[e] Revised figures.

Native asphalt and related bitumens produced in the United States in 1918, by months and varieties.

Month.	Bituminous rock (incomplete).		Gilsonite		Ozokerite.		Other bituminous substances.[a]		Total.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
January	2,215	$6,695	4,183	$77,814	.....	.....	240	$2,634	6,638	$87,143
February	2,971	8,871	3,774	75,165	.....	.....	273	3,925	7,018	87,961
March	1,026	3,089	2,237	39,584	4	$4,908	697	5,038	3,964	52,619
April	1,360	4,318	1,930	37,405	7	8,589	389	2,723	3,686	53,035
May	1,034	3,369	1,856	34,107	13	15,951	.....	.....	2,903	53,427
June	2,800	11,778	1,918	39,934	5	6,135	419	2,933	5,142	60,780
July	3,615	15,537	3,008	62,956	1	1,227	930	6,510	7,554	86,230
August	2,890	14,887	3,044	66,116	4	4,908	647	5,589	6,585	91,500
September	1,568	5,303	1,740	32,850	2	2,454	10	600	3,320	41,207
October	2,135	7,107	2,528	49,283	.....	.....	25	1,500	4,688	57,890
November	1,032	3,184	1,852	39,991	[b]	.....	137	2,920	3,021	46,095
December	2,700	8,100	2,778	51,434	1	1,227	36	2,160	5,515	62,921
	25,346	92,238	30,848	606,639	37	45,399	3,803	36,532	60,034	780,808

[a] Includes grahamite and wurtzilite.
[b] Included in December.

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Native asphalt and related bitumens produced in the United States in 1918, by varieties and States.

State.	Bituminous rock (incomplete).		Gilsonite.		Ozokerite.		Other bituminous substances.		Total.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
California	3,260	$12,516							3,260	$12,516
Utah			30,848	$606,639	37	$45,399	(a)	(a)	a30,885	a652,038
Other States b	22,086	79,722					a3,803	a$36,532	a25,889	a116,254
	25,346	92,238	30,848	606,639	37	45,399	3,803	36,532	60,034	780,808

a Wurtzilite produced in Utah included in "Other States."
b Includes Kentucky, Oklahoma, and Texas.

CONDITIONS IN PRINCIPAL STATES.

California.—California, as in other recent years, led all the States in the production of domestic petroleum asphalt, its output in 1918 from 14 refineries aggregating 195,275 short tons, a decrease of 25,019, or 11.4 per cent, compared with 1917. This quantity includes solid, semisolid, and liquid products used in paving and in the manufacture of roofing and asphaltic paint. The decrease noted was unquestionably due to the steady appreciation in the value of fuel oil, at the expense of which a part at least of the petroleum asphalt produced in California is made.

As a consequence of increased costs of labor at the quarries and of the competition afforded by the 14 refineries producing petroleum asphalt in the same State, activity in the mining of bituminous rock in California was materially diminished in 1918. The output, which was only 3,260 short tons, valued at $12,516, was produced by three companies and consisted of bituminous sandstone quarried in Santa Barbara, Santa Cruz, and San Luis Obispo counties and used in road paving.

Illinois.—Three refineries operating on petroleum produced in the Illinois field manufactured in 1918 100,952 short tons of petroleum asphalt, valued at $1,315,001. Illinois ranked third in the quantity of petroleum furnished to the asphalt industry.

Oklahoma.—The contribution of Oklahoma to the supply of asphalt in 1918 was made by three operators and consisted of 112,232 short tons of petroleum asphalt, valued at $1,357,676, an average price of $12.10 a ton, and of a small output of grahamite mined by the Fort Smith Asphalt Co. in Pushmataha County and used in the manufacture of roofing. Extensive operations were begun in Murray County in 1918 by the Continental Asphalt Co., of Oklahoma City, and though the production of this company did not reach large proportions in that year, it controls a deposit of good bituminous limestone and is preparing to market this product in large quantities. Oklahoma ranked second in the quantity of pertoleum furnished to the asphalt industry.

Utah.—The contribution of Utah to the asphalt industry of the United States in 1918 consisted wholly of bitumens and pyrobitumens. The production in that year aggregated 31,072 short tons, valued at

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$663,258, and consisted of gilsonite from Uinta County, ozokerite from Wasatch County, and wurtzilite from Carbon County. The demand for gilsonite was strong, and shipments of this bitumen, though slightly less than those in 1917, amounted to 30,848 short tons, valued at $606,639. Only one company produced wurtzilite in 1918, and the output was small. The output of ozokerite in 1918 was 74,000 pounds, valued at $45,399, compared with 36,000 pounds, valued at $1,000, in 1917.

The interest in oil shale in northeastern Utah monopolized the attention that is normally directed to the expansion of markets for the other hydrocarbon minerals with which Utah is so richly endowed and to the improvement of facilities for satisfying those markets, and no new properties were opened in 1918.

In 1918, as in 1917, extensive experimental work was done in northeastern Utah with a view to producing crude petroleum from bituminous shales.

Other States.—The Geological Survey is unable to show the quantity of petroleum asphalt produced in 1918 from oil of Kansas, Louisiana, Ohio, and Texas grades or the output of native asphalt and related bitumens in Kentucky, Oklahoma, and Texas, without disclosing the operations of individual companies. The total quantity of petroleum asphalt produced in 1918 from oil furnished by the former group of States was 119,116 short tons, valued at $2,165,684, and the output of native bitumens and related materials in the latter group was 25,702 short tons, valued at $105,034. One company produced solid asphaltic material from Kansas petroleum in 1918. The production of asphaltic material in Kentucky in 1918, as in 1917, was restricted to one property in Edmonson County operated by the Kentucky Rock Asphalt Co. The entire output consisted of bituminous sandstone which was used in the paving of city streets and country roads. Two companies produced asphalt from Louisiana petroleum in 1918. Petroleum imported from Mexico was also extensively used in Louisiana in the manufacture of asphalt. The Craig Oil Co., of Toledo, Ohio, contributed a substantial quantity of asphaltic flux produced from Lima-Indiana oil to the country's supply of asphalt in 1918. No deposits of native asphalt in Ohio are known. The contribution of Texas to the output of asphaltic material consisted of petroleum asphalt manufactured from Texas crude oil and of bituminous limestone quarried from a deposit near Cline, Uvalde County, by the Uvalde Rock Asphalt Co., and used in road and street paving.

In addition to the production already mentioned in this section the following States contributed to the output of refined asphalt in 1918 through refineries treating asphaltic oils produced in other States or imported from Mexico as well as crude native asphalt imported from Trinidad and Venezuela: Iowa, Indiana, Maryland, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, and Virginia.

Although Arkansas contains deposits of asphalt and an experiment in paving the streets of Little Rock with asphaltic material from Pike County was made several years ago, there was no commercial production in 1918.

Some of the richest oil shale in the United States is found in western Colorado, and considerable experimental work with a view to producing asphaltic material from it was done in 1918. However, there was no commercial production in that year.

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IMPORTS.

NATIVE ASPHALT.

Native asphalt imported for consumption in the United States, 1913–1918.

Year.	Crude.		Dried or advanced.		Bituminous limestone.		Total.	
	Quantity. (short tons).	Value.	Quantity. (short tons).	Value.	Quantity. (short tons).	Value.	Quantity. (short tons).	Value.
1913	[a]207,033	$738,452	[b]14,750	$133,336	6,395	$38,823	228,178	$910,611
1914	137,352	664,558	.....	.....	1,705	11,060	139,057	675,618
1915	135,276	661,356	.....	.....	2,976	19,001	138,252	680,357
1916	147,383	732,917	.....	.....	330	1,795	147,713	734,712
1917	187,473	978,087	.....	.....	413	15,028	187,886	993,115
1918	114,686	624,967	.....	.....	39	2,523	114,725	627,495

[a] Includes dried or advanced asphalt for last three months of 1913.
[b] Last three months of 1913 included in crude asphalt.

Asphaltic material imported into the United States, 1916–1918, by countries.

[Gross imports.]

Source.	1916		1917		1918	
	Quantity (long tons).	Value.	Quantity (long tons).	Value.	Quantity (long tons).	Value.
Europe:						
Switzerland	295	$1,795	.....	.....	.....	.....
England	794	8,599	1,784	$11,370	42	$482
North America:						
Canada	124	1,642	88	1,889	197	4,112
Mexico	22	381	5,171	94,594	11,579	96,125
West Indies:						
Barbados	123	6,279	51	4,855	49	5,047
Trinidad and Tobago	92,858	494,740	98,458	553,969	52,492	327,091
Other British West Indies	520	23,470	5,762	24,568	.....	.....
Cuba	524	12,701	4,210	33,552	50	1,783
South America:						
Colombia	.....	.....	120	5,271	.....	.....
Venezuela	36,626	185,095	52,165	263,600	38,024	192,855
Oceania:						
Philippine Islands	1	10	.....	.....	.....	.....
	131,887	734,712	167,809	993,668	102,433	627,495
Equivalent in short tons	147,713	.....	187,946	.....	114,725	.....

The following tables compiled from data supplied by the Joint Information Board on Minerals and Derivatives and the United States Shipping Board shows the monthly trend of the import trade of the United States in asphaltic material in 1917 and 1918:

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Asphaltic material imported into the United States in 1917, by months and countries, in long tons.

[Gross imports.]

Source.	District of entry.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.
Barbados	New York				16			7			11		17	51
Canada	Michigan	22	27						22			9		80
	Vermont	8												8
		30	27						22			9		88
Colombia	New York			49	4			10		51			6	120
Cuba	do		25	144	3,719	14	132				126	50		4,210
England	New York												1,550	1,550
	Philadelphia			28	12						57			97
	San Francisco	42											52	94
	Washington		43											43
		42	43	28	12						57		1,602	1,784
Mexico	Galveston						575	600			660	194		2,029
	Maine and New Hampshire				1									1
	New York		21								2		4	27
	Rhode Island									5				5
	Sabine								368	908	874	456	453	3,059
	Southern California								50					50
			21		1		575	600	418	913	1,536	650	457	5,171
Trinidad	Florida		1,375											1,375
	Galveston	1,888				4,608								6,496
	Mobile	5,160	1,177	1,956	825								1,200	10,318
	New Orleans		2,400											2,400
	New York	3,050	7,186	2,400	4,229	2,998	10,426	6,757	4,563	9,400	7,602	5,040	14,218	77,869
		10,098	12,138	4,356	5,054	7,606	10,426	6,757	4,563	9,400	7,602	5,040	15,418	98,458
Venezuela	do	7,580	3,555	3,604	3,937		7,937	4,195		8,433	4,197		8,418	52,165
Other British West Indies	do								10	5,752				5,762
		17,758	15,809	8,481	12,743	7,620	19,070	11,569	5,013	24,549	13,529	5,749	25,918	167,809

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Asphaltic material imported into the United States in 1918, by months and countries, in long tons.

[Gross imports.]

Source.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Canada	.....	1	41	.....	49	44	41	16	.....	.....	.....	5	197
Mexico	1,436	391	11	2,454	2,227	1,326	1,000	1,506	422	651	153	2	11,579
Trinidad and Tobago	8,581	3,070	1,115	.....	1,120	6,437	50	9,069	10,100	9,700	3,250	.....	52,492
Venezuela	4,142	.....	8,281	4,252	4,269	4,264	.....	4,211	4,298	.....	4,307	.....	38,024
Other countries	42	8	1	10	.....	.....	.....	16	.....	64	.....	.....	141
	14,201	3,470	9,449	6,716	7,665	12,071	1,091	14,818	14,820	10,415	7,710	7	102,433

The foregoing tables show that the West Indies and Venezuela are the principal foreign contributors to the supply of native asphalt in the United States. The quantity of asphaltic material imported for consumption in this country in 1918 was 114,725 short tons, valued at $627,495, a decrease of 73,161 tons, or nearly 39 per cent, in volume, and of $365,620, or 37 per cent, in value. It is apparent that imports of asphaltic material from all countries except Canada and Mexico declined materially in 1918. This condition is ascribed chiefly to the shortage of shipping and to the consequent curtailment of imports in that year, and in part to the competition of domestic and Mexican petroleum asphalt. It is believed that imports will increase in 1919.

OZOKERITE AND OTHER MINERAL WAXES.

The following table shows the receipts from foreign sources of mineral wax, including ozokerite, ceresine, and various compounded products, of which these waxes form the base, entered for consumption in the United States during the last six years:

Ozokerite and other mineral waxes imported for consumption in the United States, 1913–1918.

Year.	Quantity (pounds).	Value.	
		Price per pound.	Total.
1913	7,141,514	$0.077	$549,992
1914	8,191,529	.061	498,695
1915	2,795,256	.075	210,019
1916	3,007,676	.065	196,185
1917	899,405	.101	90,510
1918	1,809,459	.082	147,805

The following scale of wholesale "spot" prices for ozokerite and other mineral waxes was in effect in the New York market at the end of 1918:

	Cents per pound.
Ozokerite, crude brown	35–36
Ozokerite, black, 164° F	60–61
Ozokerite, 182° F	78–79
Montan wax, crude	35–36
Ceresine, yellow	16–18
Ceresine, white	18–25

Because of the scarcity of supply other varieties of mineral wax were quoted as nominal.

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ICHTHYOL.

The following table, compiled from the records of the Bureau of Foreign and Domestic Commerce, shows the quantity and value of ichthyol and ichthyol substitutes imported for consumption in the United States during the last six years.

At the beginning of 1918 prices for true ichthyol in the New York market ranged from $30 to $36 a pound, but were nominal throughout the greater part of the year. Prior to the war the world's supply of ichthyol came from deposits of asphaltic material in Austria.

Ichthyol and ichthyol substitutes imported for consumption in the United States, 1913–1918.

Year.	Quantity (pounds).	Value.	Year.	Quantity (pounds).	Value.
1913	58,485	$83,034	1916	116,738	$93,762
1914	61,416	86,415	1917	58,397	36,232
1915	24,921	28,560	1918	65,752	39,452

EXPORTS.

The export trade of the United States in 1918 in unmanufactured asphalt decreased about 26.6 per cent in quantity but only 1.6 per cent in value, compared with 1917. The value (quantity not available) of asphalt products, including roofing compounds and asphalt-saturated fabrics, exported in 1918 exceeded the value of the unmanufactured asphalt exported in that year, but was 1.5 per cent less than the value of asphalt products exported in 1917.

The following tables were compiled from the records of the Bureau of Foreign and Domestic Commerce, Department of Commerce:

Asphalt exported from the United States, 1913–1918.

Year.	Unmanufactured.		Manufactures of (value).	Total value.
	(Quantity long tons).	Value.		
1913	58,550	$1,267,625	$411,786	$1,679,411
1914	37,246	845,838	401,182	1,247,020
1915	38,203	735,952	438,685	1,174,637
1916	36,443	759,769	494,895	1,254,664
1917	26,881	587,256	585,472	1,172,728
1918	19,739	577,654	577,936	1,155,590

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Asphalt exported from the United States, 1916 and 1917, by countries.

Destination.	1916			1917		
	Unmanufactured.		Manufactures of (value).	Unmanufactured.		Manufactures of (value).
	Quantity (long tons).	Value.		Quantity (long tons).	Value.	
Europe:						
Denmark	80	$1,142				
France	510	20,159	$20,350	501	$15,877	$22,918
Greece						35
Italy	115	5,373	6,236	616	9,203	22,748
Netherlands	17	516	7			
Norway	79	2,558		40	1,395	215
Russia in Europe			2,000			
Spain	192	4,144	4,330	128	4,268	3,394
Sweden	2,774	52,657		32	675	
Switzerland	68	1,449	1,043			
England	3,427	90,190	63,000	1,641	49,463	80,074
Scotland	199	4,291	1,244			
Ireland			848	75	3,903	
North America:						
British Honduras				7,789	153,934	
Canada	24,643	427,305	197,731	11,513	215,179	207,227
Central American States:						
Costa Rica			17			4,055
Guatemala			7			938
Honduras			60	23	1,081	81
Nicaragua	1	24	30			
Panama	690	20,575	39,977	776	22,924	10,026
Salvador			244			5
Mexico	13	232	890	151	2,498	6,897
Newfoundland			158			1,748
West Indies:						
Cuba	718	18,514	15,669	525	15,929	21,462
Danish (Virgin Islands)						3
Dominican Republic			197	12	556	1,397
British:						
Jamaica	10	303	2			14
Trinidad and Tobago						40
Other British Indies			13			463
Haiti				6	313	1,318
South America:						
Argentina	613	21,501	1,378	710	18,195	12,409
Brazil	134	3,753	4,984	491	14,059	8,494
Chile	2	58	19,387	1,306	35,834	18,090
Colombia		2	306	1	30	2,050
British Guiana	12	251				915
Dutch Guiana				1	47	66
Ecuador	4	111	6			68
Peru			328	4	195	3,050
Uruguay	1,399	64,211	8,270	234	11,666	2,079
Venezuela	6	323	207	43	1,293	1,664
Asia:						
China	25	750	11,607			38,312
China, territory leased to Japan			200			
East Indies:						
British India	8	308	9,482			25,404
Straits Settlements			1,170			442
Other British			2,100			839
Dutch			280			7,033
French			527			1,118
Hongkong			21,107	21	520	15,338
Japan	312	7,948	13,763	120	4,197	20,315
Russia in Asia			37			
Siam			280			360
Oceania:						
British:						
Australia	369	10,731	22,496	12	847	8,753
New Zealand			11,751	3	182	4,328
French			99			
German			27			2,645
Philippine Islands			10,836			25,166
Africa:						
British South Africa	23	390	200			1,447
British West Africa			14			29
Madagascar				32	1,058	
Morocco				75	1,935	
	36,443	759,769	494,895	26,881	587,256	585,472
Equivalent in short tons	40,816			30,107		

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Asphalt exported from the United States in 1918, by countries.

Destination.	Unmanufactured.		Manufactures of (value).
	Quantity (long tons).	Value.	
Europe:			
France	161	$8,444	$5,712
Norway	178	5,402	
Spain	652	37,337	23,422
England	1,916	79,756	132,929
Scotland	45	1,653	
Ireland	36	2,012	
North America:			
Canada	11,247	271,005	173,350
Central American States:			
Costa Rica			22
Guatemala			372
Honduras			2
Nicaragua			213
Panama	584	27,382	6,590
Mexico	82	5,905	9,084
Newfoundland and Labrador			2,668
West Indies:			
Barbados			5
Cuba	1,126	40,293	25,937
Dutch West Indies			7
Dominican Republic			1,819
French West Indies			105
British:			
Trinidad and Tobago			180
Other British Indies			5
Haiti			143
South America:			
Argentina	148	4,200	3,361
Brazil	498	15,855	4
Bolivia			15
Chile	396	11,134	30,710
Colombia			377
Ecuador	198	6,196	10
Dutch Guiana	1	55	
British Guiana			75
Paraguay	100	3,000	
Peru	28	910	62
Uruguay			231
Asia:			
China	244	8,301	54,892
China, territory leased to Japan			200
Chosen			961
East Indies:			
British India	856	15,014	11,549
Straits Settlements	6	244	5,627
Other British Indies			1,574
Dutch	16	418	514
French			190
Hongkong	95	1,730	2,135
Japan	420	14,003	17,117
Siam	23	520	481
Oceania:			
British:			
Australia	352	10,345	30,530
New Zealand	209	4,064	9,665
French			2
German			8
Philippine Islands	88	1,495	21,337
Africa:			
British South Africa	15	495	3,519
British West Africa			57
British East Africa			168
Portuguese Africa	19	486	
	19,739	577,654	577,936
Equivalent in short tons	22,108		

CONSUMPTION.

The quantity of asphaltic and allied material actually consumed in the United States is not susceptible of accurate determination on the basis of the statistics collected by the Geological Survey. The sum of the quantity produced from domestic deposits and manu-

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factured from domestic and Mexican petroleum plus the quantity imported, less the quantity exported in a given year, provides, however, an approximation of the quantity consumed that is not without value in the absence of more specific data. The following table shows the approximate quantity of asphalt and related bitumens available for consumption in the United States in 1918, it being assumed that stocks vary little from year to year:

Asphalt and related bitumens produced and imported in the United States in 1918.

Variety.	Production.		Imports.		Total.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Domestic petroleum asphalt:						
Paving asphalt	164,704	$2,418,531			164,704	$2,418,531
Binders and fillers	16,841	272,842			16,841	272,842
Other solid and semisolid products	96,621	1,680,369			96,621	1,680,369
Road oil	78,830	808,038			78,830	808,038
Flux	160,187	2,117,889			160,187	2,117,889
Other liquid products	10,392	137,535			10,392	137,535
	527,575	7,435,204			527,575	7,435,204
Mexican petroleum asphalt:						
Paving asphalt	79,884	1,255,853			79,884	1,255,853
Binders and fillers	68,638	1,029,230			68,638	1,029,230
Other solid and semisolid products	189,859	3,690,138			189,859	3,690,138
Road oil	28,501	404,720			28,501	404,720
Flux	189,460	2,432,160			189,460	2,432,160
Other liquid products	93,902	1,511,919			93,902	1,511,919
	650,244	10,324,020			650,244	10,324,020
Total petroleum asphalt	1,177,819	17,759,224			1,177,819	17,759,224
Native asphalt			114,686	$624,967	114,686	624,967
Bituminous rock	25,346	92,238	39	2,528	25,385	94,766
Gilsonite	30,848	606,639			30,848	606,639
Grahamite and wurtzilite	3,803	36,532			3,803	36,532
Ozokerite and other mineral waxes	37	45,399	905	147,805	942	193,204
Ichthyol and ichthyol substitutes			33	39,452	33	39,452
	60,034	780,808	115,663	814,752	175,697	1,595,550
	1,237,853	18,540,032	115,663	814,752	1,353,516	19,354,784

Exports of unmanufactured asphalt from the United States in 1918 aggregated 22,108 short tons. On the foregoing basis the consumption of asphaltic material in the United States during the last four years is shown by the following table:

Asphaltic material consumed in the United States, 1915–1918.

	Short tons.
1915	1,225,447
1916	1,467,657
1917	1,587,284
1918	1,331,408

The estimated quantity of asphaltic material consumed monthly in the United States during the first six months of 1918 is indicated by the following table of sales and by the accompanying diagram (fig. 65) prepared by the Joint Information Board on Minerals and Derivatives. As the diagram was based upon a preliminary estimate made early in the year 1918 it does not agree in all

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respects with preceding statistics. Figures in this diagram showing production and sales relate only to solid and semisolid petroleum asphalt.

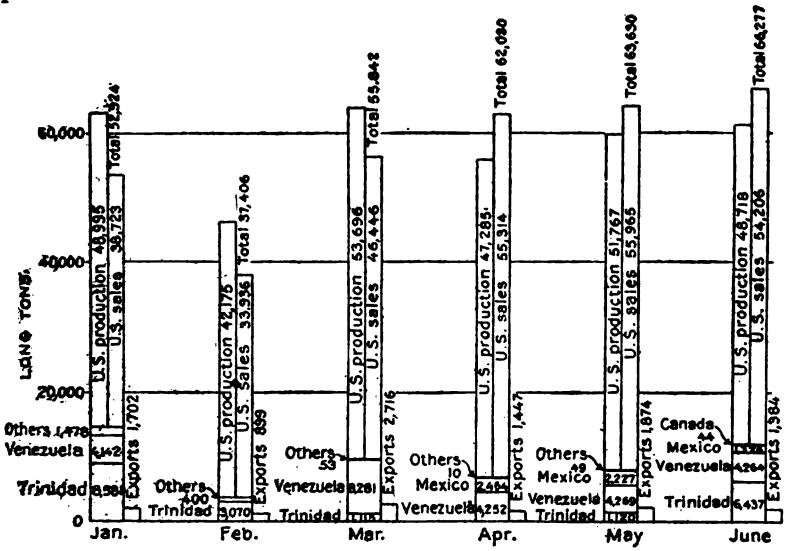

FIGURE 65.—Diagram showing production, imports, exports, and sales of asphalt and related bitumens in the United States during the first six months of 1918.

Asphalt and related bitumens sold in the United States during the first six months of 1918, by months and varieties, in short tons.

Variety.	January.	February.	March.	April.	May.	June.	Total.
Petroleum asphalt:							
Solid and semisolid products	43,370	38,008	52,019	61,952	62,681	60,711	318,741
Liquid products [a]	28,409	31,322	51,549	52,210	56,332	48,829	268,051
Total petroleum asphalt	71,779	69,330	103,568	114,162	119,013	109,540	587,392
Bituminous rock	2,395	3,201	1,214	11,293	1,086	2,820	22,009
Other native bitumens and pyrobitumens	4,001	3,684	2,834	2,511	2,577	2,539	18,146
Grand total	78,175	76,215	107,616	127,966	122,676	114,899	627,547

[a] Includes products sold or used for fuel as follows, in short tons: January, 7,538; February, 9,201; March, 14,120; April, 15,970; May, 10,694; June, 10,154; total, January to June, inclusive, 77,677.

STOCKS.

Stocks (incomplete) of domestic and Mexican asphalt and related bitumens in the United States at the end of each month during the first half of 1918, by varieties, in short tons.

Variety.	January.	February.	March.	April.	May.	June.
Petroleum asphalt:						
Solid and semisolid products	107,264	117,687	126,187	115,804	116,137	110,606
Liquid products	52,915	49,479	53,515	45,882	41,575	38,499
Total petroleum asphalt	160,179	167,166	179,702	161,686	157,712	149,105
Bituminous rock	5,000	5,000	5,000	5,000	5,000	5,000
Other native bitumens and pyrobitumens	1,227	1,699	1,889	1,728	1,014	856
	166,406	173,865	186,591	168,414	163,726	154,961

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Stocks (incomplete) of domestic and Mexican asphalt and related bitumens in the United States on Dec. 31, 1918, by varieties, in short tons.

Variety.	Domestic.	Mexican.	Total.
Petroleum asphalt	50,567	67,555	118,122
Bituminous rock			
Gilsonite	1,925		1,925
Ozokerite and wurtzilite	151		151
	52,643	67,555	120,198

OCCURRENCE, PROPERTIES, AND USES.

Owing to the increased interest in the larger use of asphalt and in order that prospective producers and users may be fully informed of the value of asphalt and related bitumens as a raw material from which many useful products may be manufactured, a brief discussion of the occurrence, distribution, properties, and uses of asphaltic material is given herewith. Much of the information presented is based upon the work of Abraham, Richardson, Northrop, Eldridge, Hubbard, and others, and liberal use has been made of their experiments.

DEFINITIONS.

The following definition, adopted in substance and promulgated by the American Society for Testing Materials, has been generally indorsed in this country:

> The term "asphalt" comprises solid or semisolid native bitumens, bitumens obtained by refining petroleum, and bitumens obtained by combining native petroleum bitumens with petroleum or its derivatives, consisting largely of complex cyclic or bridge hydrocarbon compounds fusible upon the application of heat.

The raw materials of the asphalt and allied industries of the United States consist of petroleum, of native asphalt relatively pure or associated with mineral matter, and of ozokerite, gilsonite, grahamite, and wurtzilite. According to the organic theory, petroleum is a mineral oil produced by geodynamic forces from certain types of organic débris. Native asphalt is a bitumen resulting from the metamorphosis of asphaltic petroleum. It occurs both in a relatively pure state and in combination with various proportions of sandstone, limestone, shale, and other rock. If the inorganic mineral content is large, it is called bituminous rock. Ozokerite is a native mineral wax resulting from the metamorphosis of paraffinaceous petroleum; refined ozokerite is called ceresine. Gilsonite and grahamite are asphaltites derived from petroleum. Gilsonite is one of the purest known hydrocarbons, but grahamite often contains a large proportion of inorganic impurities. Both fuse at a higher temperature than asphalt. Wurtzilite is an asphaltic pyrobitumen that yields bitumens on destructive distillation and like them is derived from petroleum. Other bituminous substances are known to exist in this country, but they are of no present commercial importance. There are no well-defined lines of demarcation between some of the types of asphaltic material and allied substances. Each class grades into another, and specimens are frequently found that have characteristics common to more than one variety.

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The nomenclature of the important raw materials of the domestic asphalt and allied industries is given in the following table, which follows roughly the classification used by Abraham in "Asphalt and allied substances."

Raw materials of the asphalt and related industries of the United States.

Genus.	Species.	Member.
Bitumens.	Petroleum.	Asphaltic. Mixed base. Paraffinaceous.
	Native asphalt.	Relatively pure. Relatively impure (bituminous rock).
	Asphaltites.	Gilsonite. Grahamite.
	Native mineral wax.	Ozokerite.
Pyrobitumens.	Asphaltic pyrobitumens.	Wurtzilite (trade name elaterite). Asphaltic pyrobituminous shales.

ORIGIN.

Deposits of asphalt and related bitumens are found in the United States in strata of all systems from the Ordovician to the Recent. The oldest formations have been observed in Oklahoma, and the youngest, which consist of sand impregnated with bitumen of earlier origin, occur near Carpinteria, Calif., though small superficial deposits of brea are well distributed throughout the country. Bitumens and pyrobitumens occur in seepages, springs, lakes, subterranean "pools," impregnated rocks, and veins, though seepages and springs rarely yield asphaltic material of commercial value. Petroleum accumulates in porous sandstone and limestone underlain and overlain by more or less impervious rock in upfolds, downfolds, and other structural features called anticlines, synclines, monoclines, domes, and terraces. Like some of the varieties of asphalt, petroleum is found in strata of all systems from Cambrian to Quaternary, but the most prolific sources are in strata of the Carboniferous and Tertiary.

The formation of asphalt, related bitumens and pyrobitumens presupposes the existence of petroleum containing asphaltic hydrocarbons, and that of ozokerite presupposes the existence of paraffinaceous petroleum. It is apparent from Plate IV and from the foregoing discussion that the deposits of asphalt and petroleum in this country are closely related both geographically and stratigraphically. Though there is some difference of opinion concerning the origin of petroleum, it is well established that when once formed it is slowly changed by geodynamic forces into asphalt and other bituminous substances, if conditions are favorable. Crude petroleum contains a large percentage of hydrogen and simple hydrocarbons. When it is subjected to heat and pressure under favorable conditions a large volume of hydrogen is eliminated, resulting in the enrichment of the

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residual hydrocarbons and their conversion into more complex compounds both chemically and physically. This is the metamorphic process. According to Richardson[1] colloidal clay accelerates the process by acting as a catalyzer. As the result of studies of the famous pitch lake in Trinidad, British West Indies, he concludes that petroleum is converted into asphalt by emulsification with clay, sand, and water by means of natural gas at high pressure. Maltha and other soft asphalts, hard asphalt, the asphaltites (gilsonite and grahamite), the asphaltic pyrobitumens (elaterite and wurtzilite), and asphaltic pyrobituminous shales are probably successive stages in the metamorphosis of asphaltic petroleum. If the petroleum is of paraffin base, ozokerite and other mineral waxes are sometimes formed.

DISTRIBUTION.

The known deposits of asphalt and related bitumens in this country, somewhat like the areas in which crude petroleum is produced, may be roughly assigned to four major regions (see Pl. IV), as indicated in the following table:

Deposits of asphalt and related bitumens in United States.

Region and variety.	State.	County.
Appalachian.		
Pure native asphalt	Kentucky	Breckenridge and Grayson.
Bituminous rock	do	Breckenridge, Carter, Edmonson, Grayson, Logan, and Warren.
Grahamite	West Virginia	Ritchie.
Mid-Continent.		
Pure native asphalt	Arkansas	Pike.
Bituminous rock	do	Pike and Sevier.
Impsonite	do	Scott.
Bituminous rock	Missouri	Lafayette.
Pure native asphalt	Oklahoma	Carter and Murray.
Bituminous rock	do	Atoka, Carter, Comanche, Garvin, Jefferson, Johnson, Le Flore, Love, McCurtain, Marshal, Murray Pontotoc, and Stephens.
Grahamite	do	Atoka, Pushmataha, and Stephens.
Impsonite	do	Le Flore and Murray.
Bituminous rock	Texas	Burnet, Montague, and Uvalde.
Rocky Mountain.		
Grahamite	Colorado	Grand.
Impsonite	Nevada	Eureka.
Pure native asphalt	Utah	Box Elder and Uinta.
Bituminous rock	do	Carbon, Grand, Uinta, and Utah.
Gilsonite	do	Uinta.
Wurtzilite	do	Do.
Ozokerite	do	Utah and Wasatch.
California.		
Pure native asphalt	California	Kern, San Luis Obispo, and Santa Barbara.
Bituminous rock	do	Mendocino, Monterey, Orange, San Luis Obispo, Santa Barbara, and Santa Cruz.

The richest and most extensive deposits of asphalt and related bitumens in this country are found in Oklahoma, though Utah contains the largest variety. Small deposits of asphaltic material occur in Alabama, Illinois, Indiana, and Louisiana, but they have not been

[1] Richardson, Clifford, The nature and origin of petroleum and asphalt: Met. and Chem. Eng., vol. 16, No. 1, p. 25, 1917.

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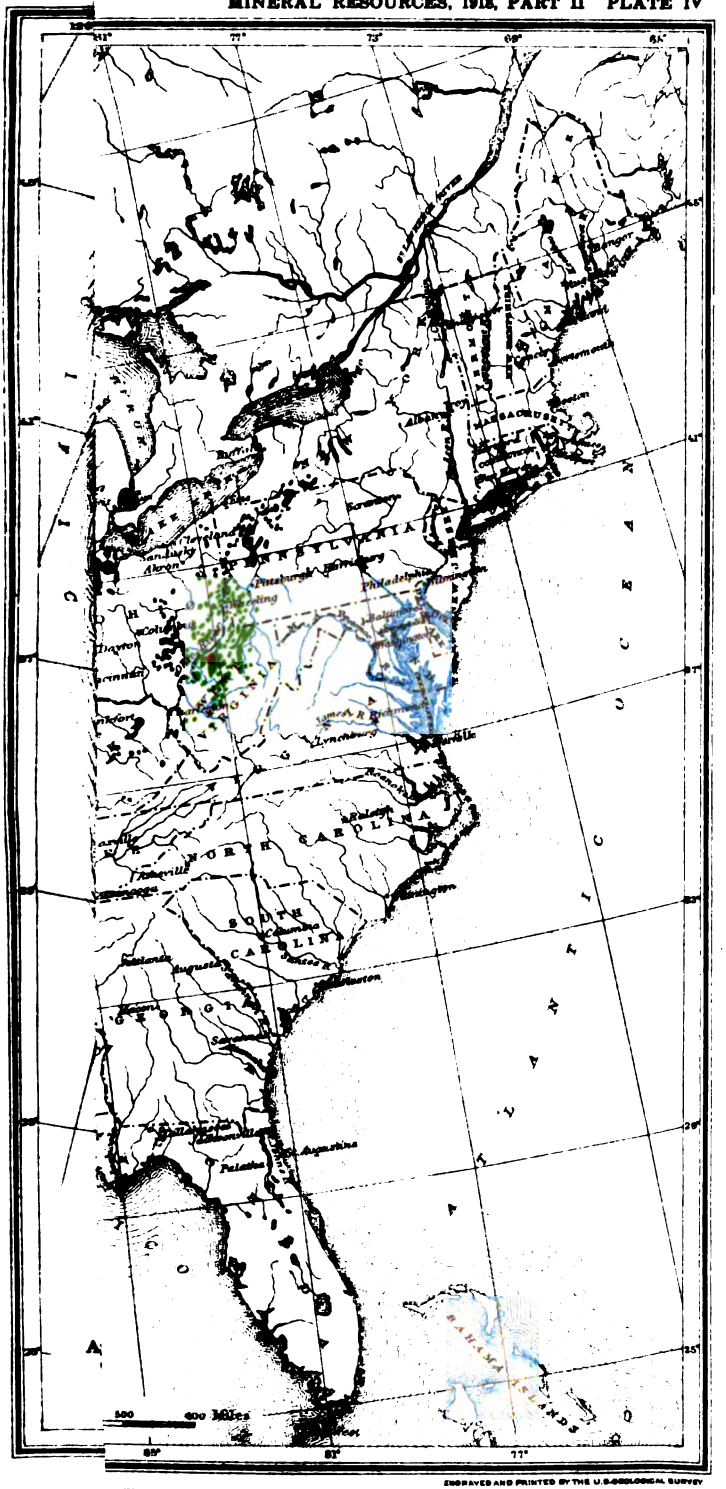

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RELATED BITUMENS

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commercially developed. Asphaltic pyrobituminous shale is found in Wyoming, Colorado, Utah, and other States, but it has never been used commercially as a source of asphalt.

The following quotation[1] shows the general geographic distribution and stratigraphic range of asphalt and related bitumens in the United States:

The distribution of asphalts and bituminous rocks in the United States is wide. The asphaltites are found in West Virginia, Oklahoma, and Utah; bituminous limestones in Oklahoma, Texas, and Utah; bituminous sandstones in Kentucky, Missouri, Oklahoma, Texas, Utah, and California;[2] earthy bitumen of great purity, occurring as veins, in California; brea, it is possible, occurs in all petroleum areas, but in the present investigation it was found only in Oklahoma, Wyoming, and California, although small bodies are reported to occur in Montana. The localities of these several occurrences are shown on the general map of the United States (Pl. IV).

The stratigraphic range of the bitumens and their compounds is as wide as their geographic distribution. Their oldest association observed is with the Ordovician shale of the Tenmile region in eastern Oklahoma, where impsonite, an asphaltite closely related to albertite, occurs in vein form. Other veins of like material, as well as a bituminous sandstone, occur in the series of Ordovician sandstone overlying the shales along the Oklahoma-Arkansas line. In central Oklahoma, in the Buckhorn district, are other bituminous sandstones, also of Ordovician age, though perhaps not to be correlated with the foregoing. Above these, in direct succession, is the summit limestone of the Ordovician, at least for this locality—a massive bed of variable thickness the maximum being approximately 400 feet. The entire body of the rock is varyingly impregnated with bitumen, the more highly enriched portions to an average of 6 to 8 per cent. In this same locality the lower coal measures also, at one or more horizons, are richly infiltrated with bitumen, one of their limestones carrying an average of 14 per cent. The lower coal measures are unconformable with the underlying formations, and the occurrence of bitumen at the several horizons suggests a common source and origin for it, and an inflow to its present reservoirs, perhaps subsequent to the laying down of all the sediments involved, if not, indeed, subsequent to their folding. On the other hand, from the presence in the coal measure conglomerate of an occasional pebble, believed to be of Ordovician bituminous sandstone, particularly observed by Mr. Taff, there may have been two or more distinct flow periods.

West and south of the Arbuckle Mountains the coal measures again carry bitumen in some of their members—grits and limestones. These horizons, however, may be quite different from those in the Buckhorn region.

In the vicinity of Higginsville, Mo., the Warrensburg sandstone, occupying what Mr. Arthur Winslow, the State geologist, considers a channel of erosion in the coal measures, but assigned to the Carboniferous, is also infiltrated with bitumen to about 6 per cent.

In West Virginia the grahamite vein, which has brought much renown to the region of its occurrence, occupies a vertical fissure in the Waynesburg sandstone and adjoining beds above and below horizons in the upper productive and upper barren coal measures of the Carboniferous age.

The bituminous sandstones of Kentucky are closely successive members of the Chester formation and the basal portion of the coal measures, and all, at one point or another, are impregnated to a degree sufficient to render them economically available for paving purposes, their contents ranging between 5 and 8 per cent.

The Permian, or what is at present accepted as the Permian, in central Oklahoma has been penetrated by fissures through which petroleum has risen into its superficial sandy members, and has also been converted to brea as surface deposits. This occurs at Wheeler, a settlement about 40 miles west of Ardmore. The locality is practically that of the enriched coal measure sandstones south of the Arbuckle Mountains, and there is little doubt that a common source supplied all the different horizons that now constitute the exposed storage reservoirs of the former fluid petroleum.

[1] Eldridge, G. H., The asphalt and bituminous rock deposits of the United States: U. S. Geol. Survey Twenty-second Ann. Rept., pt. 1, pp. 227–231, 1901.

[2] Since the writer's field investigation indefinite accounts of bituminous sandstones in Alabama and Illinois have appeared in certain newspapers.

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The Trinity sand of the Lower Cretaceous is a bitumen-bearing formation at many points in its area of outcrop in southern Oklahoma and northern Texas. This is particularly the case where it rests upon the Carboniferous, an occurrence that is significant of the derivation of its bitumen from a source perhaps identical with that from which the several members of the coal measures have derived theirs.

The Glen Rose formation, also a member of the Trinity division of the Lower Cretaceous, in one of its limestones carries the bitumen of the deposits of Post Mountain, near the town of Burnet, Burnet County, Tex. The Anacacho formation of the Texas Upper Cretaceous, corresponding to a horizon near the base of the Montana of the Rocky Mountain section, carries the rich bituminous limestones extensively quarried in the vicinity of Anacacho Mountain, 18 miles west of Uvalde, in southern Texas. In this connection the presence of important oil horizons in the Montana formation of the Florence oil field in Colorado is not unworthy of note.

The Middle Park formation of Middle Park, Colo., largely a terrane of eruptive material and a correlative of the Denver of the plains—a formation for the present termed post-Laramie, without assignment to Cretaceous or Tertiary—also carries bitumens. The deposit occurs in the northern portion of Middle Park, almost in the heart of the Rocky Mountains. It is here an asphalt resembling gilsonite and occupying an irregular fissure or series of fissures in the clays, sandstones, and conglomerates of the formation referred to. The occurrence is, so far as known, limited to the immediate region in which it is found, and is thus comparatively isolated, the nearest asphalt being the gilsonite found along the Colorado-Utah line, 150 miles distant.

The bitumens of the Tertiary horizons are apparently confined to the West—to Colorado, Utah, and California. The various divisions of the Eocene in eastern Utah and just across the line in Colorado are noted both for the variety of their asphalts and for the size of their veins. It is in this region, of the White and Green Rivers and the celebrated Book Cliffs, that the great veins of uintaite are found and that the minor seams of wurtzilite, ozokerite, and nigrite occur. Bituminous limestones are also of wide distribution, though confined to the Green River shales. The asphaltites occur in fissures both in this formation and in those overlying, especially the Bridger and Uinta. Maltha springs also occur, and even petroleum is reported in one of the upper members of the Cretaceous, a few miles east of the Utah-Colorado line. The Green River shales are noted throughout the West for their bitumen contents, and it is surmised that they are the source of the asphalts, at least, of this vast area. The variation in the ultimate material as it to-day fills one fissure or another is perhaps due in part to a change somewhat allied to fractional distillation in petroleum technology and in part to the degree to which oxygen absorption has been carried on. In any event, the variety of bitumen found can hardly excite wonder when considered as to the origin of the material and the differentiations that take place in artificial distillation. It is, indeed, to be expected.

The occurrence of bitumens in the Neocene is confined to California. The rocks of this period here embrace a heavy series of shales with local sandstone, tuffs, etc.—The Monterey formation; a conspicuous body of massive sandstones with a minor proportion of shales known as the San Pablo formation, but in doubt as to its position as a member of the Miocene or Pliocene, and hence in the region of its occurrence regarded as Middle Neocene; and a succession of sandstones, conglomerates, and clays, probably Pliocene, but for the present termed Upper Neocene, with the specific name Paso Robles assigned to it.

In addition to the foregoing there are certain and important sandstones and sand aggregates of somewhat doubtful age, but where encountered seeming to lie beneath the shales of the Monterey rather than in them, and often against and upon granite. Such is their occurrence in the vicinity of Santa Cruz, and again at one or two points in the range bordering the Salinas Valley on the east. These sandstones are locally heavily impregnated with bitumen, and near Santa Cruz are extensively quarried for paving purposes in San Francisco and elsewhere.

The Monterey formation is of particular importance, in that for almost the entire length of the State its terrane is more or less conspicuously marked with petroleum or maltha seepages, while its sandy members may appear as minor storage reservoirs of oil, this now altered at the outcrop to a material of pasty consistency, and forming with the sand grains an asphaltic compound of considerable richness. Such sandy beds occur at Point Arena, in the San Antonio Val-

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ley, and in the region of the Sisque. The shales of the Monterey are not only generally bituminous, but some of their more arenaceous and porous members are also especially rich, doubtless having received an inflow of petroleum from their adjoining and less open associates. It is in the shales of the Monterey, too, as well as in the Middle Neocene, that veins of the more solid bitumens, mixed with clastic material derived from the country rock, are found. Except for the clastic material, the bitumen would resemble in structure the asphaltites, though still differing from them in other features. Veins of this description are conspicuous in the vicinity of Santa Maria, Santa Barbara, and Asphalto. Near the latter place the asphaltic material is intimately related to, even associated with, petroleum.

The San Pablo formation, at least that portion of it in the San Luis Range, has been converted into a vast storage reservoir. It is the surface terrane over an area of nearly 50 square miles a short distance southwest of San Luis Obispo, and perhaps half its outcrop here shows impregnation with bitumen in greater or less degree, locally to a high degree. In the same region scattered bodies of the Paso Robles formation have also been infiltrated where resting on the San Pablo or the Monterey.

The San Pablo is also, perhaps, represented in the region of the Sisque, 40 miles southeast of Santa Maria, where along the southern base of the San Rafael Range is a highly enriched body of sandstone, of doubtful correlation from its structural association with recognized Monterey sandstones, but possibly of the age suggested. It is locally one of the richest sandstones in California.

In the region of the Graciosa Hills, 6 to 10 miles south of Santa Maria, there rests upon the Monterey, unconformably, a heavy body of loosely coherent sands or sandstone commonly regarded as Pliocene. Cracks have developed in the formation, which have been filled with bitumen carrying from 30 to 60 per cent of clastic matter. The material resembles in general appearance that already referred to as of vein form in the Middle Neocene near Asphalto. Here, however, it has not yet been found in association with petroleum.

Post-Pliocene sandstones are found with small gash veins and other irregular but more or less extensive bodies of the solid bitumens in the region of More's Landing, 7 miles west of Santa Barbara. A material in many ways resembling gilsonite was found as a minute pocket in the sandstone, but the mass of the bitumen is of the solid variety, mixed with 20 to 30 per cent of clastic material. Twelve miles east of this occurrence is the important petroleum-producing region of Summerland. Pleistocene or recent sands have been heavily charged with bitumen at Carpinteria, 12 miles east of Santa Barbara. They have been for the most part removed, but the continuous flow of maltha in the floor of the quarry would quickly impregnate an equal body were the excavation to be filled with fresh sand from the adjoining ocean beach.

Superficial deposits of brea are well distributed over the United States. Those observed by the writer were in Oklahoma, Wyoming, and California, the first no longer increasing from active springs, the others still forming. The source of their malthas is naturally extremely varied. In addition to the above there are doubtless many others of but little less importance scattered through the oil regions of the country.

Detailed data concerning the occurrence of asphalt and related bitumens in this country are given in the report quoted above and in a book by Herbert Abraham.[1]

The principal sources of petroleum asphalt are the semiasphaltic oils produced in Illinois and Oklahoma and the asphaltic oils produced in California, Louisiana, and Texas. (See Pl. IV.) The following quotation[2] explains the general location of the areas in which petroleum is produced in the United States:

The areas in which crude petroleum is produced in the United States are assigned to nine major fields. This division, though mainly geographic, incidentally expresses to a considerable degree differences in the characteristics of the oil produced.

[1] Asphalt and allied substances, New York, D. Van Nostrand Co., 1918.
[2] Northrop, J. D., Our mineral supplies—Petroleum: U. S. Geol. Survey Bull. 666–DD, pp. 4–8, 1918.

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1. The Appalachian field includes all areas of oil production in southwestern New York, western Pennsylvania, eastern Ohio, West Virginia, Kentucky, and Tennessee. The crude oils produced in this field range in gravity from 25° to 50° Baumé, are in the main of paraffin base, are free from asphalt and objectionable sulphur, and yield by ordinary refining methods relatively high percentages of gasoline and illuminating oils.

2. The Lima-Indiana field embraces the areas of petroleum production in western Ohio and in Indiana. The product of this field ranges in gravity from 30° to 35° Baumé and is of paraffin base, though containing a small proportion of asphalt.

3. The Illinois field includes the principal area of oil production in the southeastern part of Illinois, as well as a number of scattered pools of small individual extent in the central and western parts of the State. The oil in this field ranges in gravity from 28° to 40° Baumé and contains varying proportions of both asphalt and paraffin. * * * Aside from minor pools that may be discovered from time to time in the western part of the State, the productive oil territory in this field is believed to be now under development.

4. The Mid-Continent field includes all areas in which petroleum is produced in Kansas and Oklahoma. The oils of this field vary in composition within wide limits, ranging from asphaltic varieties that are lean in gasoline and illuminants to high-grade paraffin oils that yield a large percentage of the lighter products of distillation. The range in gravity is between 27° and 42° Baumé. Although this field is believed to have attained its maximum annual production, amounting to 115,809,792 barrels, in 1916, it is destined to remain the principal contributor to the petroleum supply of the country for many years, as its productive districts are only partly drilled, and its boundaries embrace large areas of untested and apparently not unfavorable territory.

5. The north Texas field includes a number of detached areas of oil production in the northern and east-central parts of Texas. The oils produced are in general similar to those of the Mid-Continent field, with the exception of that obtained in the Powell pool, Navarro County, which has a gravity of about 23° Baumé and is of little commercial value except as a fuel.

6. The north Louisiana field includes the areas of petroleum production in Caddo, De Soto, Bossier, Red River, and Sabine parishes. The oils of this field range in gravity from 22° to 42° Baumé and are of paraffin base, though containing ordinarily small percentages of asphalt.

7. The Gulf field includes a large number of detached oil pools associated with saline domes in southeastern Texas and southern Louisiana. Oils from the Gulf field, though variable in composition, are characterized by relatively high percentages of asphalt and low percentages of the lighter distillation products. In general they range in gravity between 15° and 28° Baumé and contain considerable sulphur, much of which is in the form of sulphureted hydrogen and is easily removed by steam before the oil is utilized. The low-gravity oils from this field are used chiefly as fuel and for the manufacture of asphalt and asphalt products. The lighter grades are refined and yield lubricating oils of superior quality.

8. The Rocky Mountain field includes all areas of petroleum production in Colorado, Wyoming, and Montana, as well as areas of prospective oil production in Utah and New Mexico. Crude oils from this field are in the main of paraffin base and yield relatively high percentages of gasoline, illuminating oils, lubricants, and fuel distillates. The greater part of the oil produced ranges in gravity from 32° to 48° Baumé and contains little or no objectionable sulphur. Heavy asphaltic oils, ranging in gravity from 18° to 24° Baumé, suitable chiefly for fuel or for the manufacture of asphalt, are obtained in certain parts of this field.

9. The California field embraces all areas of oil production in that State. The oils of this field are in the main of asphalt base and range in gravity from 12° to 35° Baumé. Relatively small quantities of paraffin-base oils are found in certain localities. About 25 per cent of the petroleum produced in California is used for fuel or for the manufacture of asphalt and asphalt products.

PROPERTIES.

Asphalt and its related bitumens and pyrobitumens consist chiefly of carbon and hydrogen, though oxygen, nitrogen, sulphur, and other minerals in varying proportions are also found in them. Some

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bituminous substances contain oxygenated bodies and paraffins that crystallize at low temperatures. As all bituminous materials contain carbon and hydrogen they are classed in the hydrocarbon group of organic compounds.

Most bituminous substances range in color from white through various shades of yellow and brown to jet black, though some possess a greenish or reddish cast. Pure mineral wax is white, and asphalts are generally dark brown, grayish black, or jet-black. At 77° F. the specific gravity of bituminous material ranges from 0.75 to 1.75. The consistency depends upon the metamorphic stage and ranges from liquid through various degrees of viscosity to brittle. Petroleum is a liquid, native asphalt is variable, the asphaltites and asphaltic pyrobitumens are relatively hard; and mineral wax varies from viscous to solid. Crude petroleum has a characteristic oily odor.

The following table[1] shows the physical and chemical properties of bituminous substances:

[1] Abraham, Herbert, Asphalts and allied substances, p. 22, New York, D. Van Nostrand Co., 1918.

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Properties of bituminous substances.

Bituminous substances.	Origin.	Physical properties.							Solubility.		Composition.
		Color in mass.	Consistency.	Luster.	Feel.	Odor.	Volatility.	Fusibility, nonmineral constituents.	Nonmineral constituents in carbon disulphide.	Sulphonation residue of 300° to 350° C. distillate.	
Bitumen	Native	Variable (light to dark).	Variable (liquid to solid).				Variable	Harder varieties are fusible.	Largely soluble.	Considerable	Hydrocarbons, substantially free from oxygenated bodies, sometimes associated with mineral matter.
Pyrobitumen	do	Dark	Comparatively hard.	Resinous to dull.	Nonadherent		Nonvolatile.	Infusible	Relatively insoluble.		Hydrocarbons which may or may not contain oxygenated bodies, sometimes associated with mineral matter.
Petroleum	do	Variable (light to dark).	Liquid		Oily	Characteristic ("oily").	Comparatively volatile.		Soluble	Considerable	Hydrocarbons, substantially free from oxygenated bodies.
Mineral wax	Native or pyrogenous.	do	Viscous to solid.	Characteristic ("waxy")	Unctuous		Comparatively nonvolatile.	Fusible	do	do	Hydrocarbons, substantially free from oxygenated bodies, containing considerable crystallizable paraffins, sometimes associated with mineral matter.
Asphalt	do	Dark	Variable	Harder varities resinous. to dull.	Adherent to nonadherent.		do	do	Largely soluble.	do	Hydrocarbons, substantially free from oxygenated bodies, containing little to no crystallizable paraffins, sometimes associated with mineral matter.
Asphaltite	Native	do	Comparatively hard.	Resinous	Nonadherent.		Nonvolatile.	Difficultly fusible	do	do	Hydrocarbons, substantially free from oxygenated bodies and crystallizable paraffins, sometimes associated with mineral matter.

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Asphaltic pyrobitumen.	....do....	....do....	....do....	Resinous to dull.	....do....	.....	....do....	Infusible...	Largely insoluble.	.....	Hydrocarbons, substantially free from oxygenated bodies, sometimes associated with mineral matter.
Nonasphaltic pyrobitumen.	....do....	....do....	....do....	....do....	....do....	.....	....do....	....do....	....do....	.....	Hydrocarbons, containing oxygenated bodies, sometimes associated with mineral matter.
Tar.....	Pyrogenous	....do....	Liquid.....	.....	Oily.....	Characteristic ("tarry").	Comparatively volatile.	.....	Largely soluble.	Comparatively little.	Variable.
Pitch.....	....do....	....do....	Viscous to solid.	Resinous to dull.	Adherent to nonadherent.	.....	Comparatively nonvolatile.	Fusible....	....do....	....do....	Do.

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USES.

WAR-TIME USES AND POSSIBILITIES.

A review of conditions in the asphalt and allied industries during the year in which the great World War terminated seems a fitting place wherein to discuss briefly the domestic sources of supply, the war-time uses and possibilities of asphalt and related bitumens, and the relation those commodities bear to a warring nation. The bitumens and pyrobitumens are used in the construction of pavements and in the manufacture of roofing, of other building material, and of rubber, products which are of great importance in time of war. Many new asphalt pavements were laid in this country in 1918 at cantonments, shipyards, and elsewhere in war work, and much asphaltic material was used in the manufacture of roofing for the thousands of temporary buildings that were erected in that year.

The domestic supply of asphalt and related bitumens is for all practical purposes unlimited; the large deposits of native asphalt have been scarcely touched; and the petroleum reserves contain an immense quantity of asphaltic material that can be obtained in the distillation process.

Petroleum refineries equipped for the manufacture of asphalt are located in practically all parts of the United States as follows:

Atlantic border:
Bayonne, N. J.; Philadelphia, Pa.; Baltimore, Md.
Interior:
Cleveland, Ohio; Lawrenceville, Ill.; Whiting, Ind.; Wood River, Ill.; Sugar Creek, Mo.; Independence, Kans.; Shreveport, La.
Gulf coast:
Destrehan and Baton Rouge, La.; and Beaumont, Port Arthur, and Texas City, Tex.
Pacific coast:
San Francisco, Bakersfield, Los Angeles, and Vernon, Calif.

The capacity of the refineries in any one of these districts is ample to care for all the asphalt requirements of the adjacent consuming territory provided the necessary supply of asphaltic oil is available.

In general paving cements now manufactured by the leading producers of petroleum asphalt are satisfactory and have in their favor the fact that the process of their manufacture yields valuable by-products—gasoline, kerosene, lubricants, and fuel oils—to the extent of approximately 50 per cent of the crude oil utilized. It must be acknowledged, however, that practically all oil asphalt manufactured in the country from Illinois, Oklahoma, Gulf coast, and Mexican petroleum is produced at the expense of fuel oil, a war necessity of equal, if not greater, importance than asphalt. It seems therefore that this country is independent of foreign asphalt, and that in case of need shipping engaged in the importation of native asphalt could be diverted to other purposes, as it was in a measure during the recent war.

The most important use of ozokerite is as acid-proof coating or backing for electrotypers' plates. Prior to the war the entire supply utilized in this country was imported chiefly from Galicia. When the foreign source of supply was cut off, a deposit near Soldier Sum-

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mit, Wasatch County, Utah, was opened, and it has produced continuously since that time. The occurrence of the Utah ozokerite as irregular and nonpersistent deposits in fissures and brecciated zones and as thin films along joint planes in little-disturbed rocks permits no quantitative estimate of the underground reserves of this mineral in the area of its principal occurrence. Many prospects and mines, at present undeveloped, have disclosed ozokerite in various places, and it is probable that production could be materially increased if the operators were assured that the present high prices for ozokerite would remain in effect for several years.

ASPHALT AS PAVING MATERIAL.

Asphalt is most largely used in this country in paving city streets and country roads. Both petroleum and native asphalts are well adapted for this purpose. Paving cement, binder, filler, road oil, and flux are obtained as a residuum in the distillation of semi-asphaltic and asphaltic petroleum. Paving cement and binder are used in the construction of asphalt pavements, filler in the manufacture of asphalt blocks, road oil to allay dust, and flux in the treatment of native asphalt. Asphalt binder is also often used in the preparation of fuel briquets. Substantially the same products are obtained from native asphalt. If properly laid and maintained, asphalt pavements are durable, clean, give rise to relatively little noise and dust, and are universally popular for both city streets and rural highways. Typical standard specifications for bituminous road materials are given in United States Department of Agriculture Bulletin 691.

Bituminous rock, a variety of native asphalt, is used in the construction of city streets and country highways. Most of the pavements in the United States have heretofore been made with imported native asphalt and petroleum asphalt, but this country contains vast quantities of bituminous rock that could be economically used for paving, and this would release a large quantity of oil suitable for fuel. European countries use large amounts of bituminous rock in road construction, and many good pavements have been made with it in the United States.

The following data, explaining the use of bituminous rock in road construction, were contributed in substance by James S. Downard, of Sulphur, Okla.:

There are two methods of using bituminous rock in paving. According to one the rock is powdered, heated, spread about 2 inches thick upon a concrete foundation, and compressed by a steam roller. According to the other the bituminous rock is crushed and utilized in macadamizing.

The advantages of a bituminous-rock pavement are based upon its origin and composition. It is a limestone or sandstone saturated by nature with asphalt, the temper of which is of secondary importance in pavement construction. Properly constructed, bituminous-rock pavements contain a high percentage of filler and no excess asphalt and therefore are attractive, permanent, and waterproof and do not roll or creep.

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Although good bituminous-rock pavements have been laid in Kansas City, Kans., Oklahoma City, Okla., and other cities, many rock-asphalt pavements constructed in the United States have been experimental and have not been successful because of the failure of the contractor to understand the nature of rock asphalt. Bituminous rock varies in quality, and each deposit must be analyzed and treated individually. One of the best known specifications is a mixture of 40 per cent bituminous limestone and 60 per cent bituminous sandstone. One-half of the bituminous sandstone should be ground finely and the remainder coarsely. Bituminous rock pavements are used in Kansas City, Kans.; Salt Lake City, Utah; San Francisco, Calif.; Ardmore, Ada, Norman, Houldenville, Pawhuska, Durant, Lawton, and Oklahoma City, Okla.; and Dallas, Bonham, Paris, Sherman, Mount Pleasant, San Antonio, Houston, and Beaumont, Tex. Some bituminous-rock pavements in Kansas City have been continuously and successfully used by heavy traffic for 20 years.

Two of the best bituminous-rock deposits in the United States for paving are in Murray County, Okla., and Uvalde County, Tex.

BITUMINOUS SUBSTANCES AS BUILDING MATERIAL.

The uses of bituminous substances, including both asphalt made from petroleum and native asphalt, as well as gilsonite, grahamite, and wurtzilite in buildings and other structures are manifold. Both viscous and liquid asphaltic products obtained from petroleum and crude native asphalt are used in the manufacture of asphaltic paints and in the treatment of felts and other fabrics for building material. Gilsonite is used in the manufacture of paint, japans, varnish, waterproofing, and insulation. Refined wurtzilite is utilized principally in the manufacture of insulation, marine and iron paints, acid-resisting compounds, and other protective coatings. The demand for wurtzilite, though small, appears to be increasing in consequence of its employment as a primary constituent of prepared flooring. In 1918 the use of grahamite in this country was restricted to roofing, but it is also suitable for the production of flooring, of varnish, and of filler for brick and stone blocks. Although these products have been marketed for relatively few years in the United States, as they are elastic, antiseptic, acid-resistant, and moisture-proof, they are in general demand among contractors and engineers, and their use is increasing.

OTHER USES.

Gilsonite has found great favor in the rubber industry. As pure rubber is sensitive to heat and cold it can not be used advantageously for making products that are exposed to extreme temperatures, but when it is mixed with gilsonite and the mixture is vulcanized the rubber undergoes changes in composition that enable it to resist variations in temperature as well as oxidation. The product of this mixture, which is called mineral rubber, is well adapted for the manufacture of rubber tires and for general outdoor use, and the demand for it is increasing.

Ozokerite is utilized in the manufacture of leather polish, sealing wax, electrotypers' wax, candles, electric insulation, carbon paper,

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and ink. Most of the output in 1918 was used as an acid-proof coating for electrotypers' plates.

Ichthyol, though not produced in the United States, is imported and used by physicians as an alterative and discutient in treating certain skin diseases. It is a brown sirupy liquid produced by the dry distillation of bituminous material containing fossil fish. True ichthyol is said to be produced only from Austrian bitumen, but it is reported that since imports from Austria were cut off by the war equally effective substitutes have been discovered.

ASPHALT INDUSTRY IN FOREIGN COUNTRIES.

NORTH AMERICA.

CANADA.

Although there are large deposits of bituminous sandstone in northern Alberta, little has been done to develop them commercially. In 1913 a brief reconnaissance of the deposits was made by S. C. Ells, of the Canada Department of Mines, and in 1914 experimental pavements were constructed in Edmonton with material from these beds. After a year's use the pavement was in good condition, and therefore it seems that the material is well suited for highway paving. However, experimental work was discontinued in 1917 because of the entrance of Mr. Ells into the military service, and so far as can be ascertained it was not resumed in 1918.

MEXICO.

As shown by the following tables, increasing quantities of petroleum, largely of asphaltic base, are produced annually in Mexico and exported to the United States for the manufacture of petroleum asphalt and other products:

Petroleum produced in Mexico, 1901–1918.

	Barrels.		Barrels.
1901	10,345	1910	3,684,080
1902	40,200	1911	12,552,798
1903	75,375	1912	16,558,215
1904	125,625	1913	25,696,291
1905	251,250	1914	26,235,403
1906	502,500	1915	32,910,508
1907	1,005,000	1916	40,545,712
1908	3,982,900	1917	55,292,770
1909	2,713,500	1918	63,828,327

Petroleum exported from Mexico to the United States, 1914–1918.

Year.	Quantity (gallons).	Value.	Year.	Quantity (gallons).	Value.
1914	682,330,948	$9,363,690	1917	1,257,207,692	$16,137,130
1915	734,095,839	9,760,859	1918	1,584,201,535	21,305,108
1916	845,277,611	11,775,377			

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Asphalt produced in the United States from Mexican petroleum, 1913–1918.

Year.	Quantity (short tons).	Value.	Year.	Quantity (short tons).	Value.
1913	114,437	$1,743,749	1916	572,387	$6,018,851
1914	313,787	4,131,153	1917	645,613	7,441,813
1915	388,318	3,730,436	1918	650,244	10,324,020

The following table was compiled from data furnished by the Pan American Union:

Asphalt produced in Mexico, 1906–1915.

Year.	Quantity (metric tons).	Value.	Year.	Quantity (metric tons).	Value.
1906	1,389	$17,174	1911	8,085	$125,322
1907	4,486	182,265	1912	30,491	462,230
1908	5,272	330,903	1913	(a)	(a)
1909	5,471	106,484	1914	(a)	(a)
1910	2,849	39,681	1915	388,318	3,733,000

a Not available.

WEST INDIES.

CUBA.

Asphalt produced in Cuba, 1906–1917.

Year.	Quantity (metric tons).	Value.	Year.	Quantity (metric tons).	Value.
1906	5,186	$26,605	1912	15,658	$87,500
1907	5,064	37,594	1913	a 1,587	30,935
1908	6,237	31,574	1914	a 879	19,491
1909	10,795	48,246	1915	a 441	11,247
1910	2,105	13,685	1916	a 489	12,486
1911	3,300	21,928	1917	a 473	13,191

a Exports.

The extent of foreign shipments of native asphalt from Cuba during the last seven years is shown by the following table, based upon data supplied by the Pan American Union:

Asphalt exported from Cuba, 1911–1917.

Year.	Quantity (metric tons).	Value.	Year.	Quantity (metric tons).	Value.
1911	3,300	$21,629	1915	441	$11,247
1912	15,655	86,303	1916	489	12,486
1913	1,587	30,935	1917	473	13,191
1914	879	19,491			

TRINIDAD.

For many years the island of Trinidad has been the chief contributor to the world's supply of native asphalt. The crude material is excavated from the famous pitch lake at the south end of the

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island by the New Trinidad Lake Asphalt Co. (Ltd.), a subsidiary of the General Asphalt Co., and although large quantities of asphalt have been taken from the deposit the excavations are soon filled with fresh material and the quantity of asphalt available seems unlimited. The deposit is approximately 120 acres in extent and of unknown depth, the deepest test that has ever been made—150 feet—having failed to reach the bottom. The shifting of underlying strata in the lake bends or breaks drilling tools driven into them. Specimens of asphalt taken at various depths indicate that the deposit is of uniform composition.

The raw material is exported to both the United States and Europe, and streets paved with Trinidad asphalt are found throughout the world, the most famous being Pennsylvania Avenue, Washington, D. C.; the Thames-Victoria Embankment, London, England; and the Avenue de Paris, leading from Paris to Versailles, France. Most of the asphalt exported to the United States is refined by the Barber Asphalt Paving Co. at its plant in Maurer, N. J. It is apparent from the following tables that exports of asphalt from Trinidad declined materially in recent years, but as this was due to the situation brought about by the war, it would seem that the resumption of normal conditions should restore this trade to its prewar proportions.

Native asphalt produced in Trinidad, 1906–1918.[a]

Year.	Quantity (metric tons).	Value.	Year.	Quantity (metric tons).	Value.
1906	136,417	$832,964	1913	[b] 283,725	[c] $1,030,540
1907	155,375	832,274	1914	[b] 147,942	[b] 789,450
1908	130,230	403,023	1915	[b] 138,210	[c] 736,760
1909	144,621	459,446	1916	[b] 133,204	[c] 698,475
1910	142,538	421,419	1917	[b] 132,742	.....
1911	[b] 182,604	[c] 603,800	1918	[b] 74,254	.....
1912	[b] 192,539	[c] 742,800			

[a] Includes small quantity of manjak produced in Barbados. [b] Exports. [c] Estimated.

The following table, presented through the courtesy of the Barber Asphalt Paving Co., shows the trend of the asphalt industry in Trinidad:

Asphalt exported from Trinidad, 1913–1918, in long tons.

Year.	To United States.			To Europe.			To other countries.			Grand total.
	Lake.	Land.	Total.	Lake.	Land.	Total.	Lake.	Land.	Total.	
1913	123,873	1,400	125,273	104,153	.....	104,153	605	.....	605	230,031
1914	67,357	2,950	70,307	75,297	.....	75,297	.....	.....	.....	145,604
1915	118,001	1,250	119,251	18,025	.....	18,025	.....	.....	.....	137,276
1916	117,719	.....	117,719	13,380	.....	13,380	.....	.....	.....	131,099
1917	119,149	.....	119,149	11,496	.....	11,496	.....	.....	.....	130,645
1918	58,528	.....	58,528	14,552	.....	14,552	.....	.....	.....	73,080

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SOUTH AMERICA.

VENEZUELA.

Native asphalt is produced from the Bermudez Lake near Guanoco, in the eastern part of Venezuela, by the New York & Bermudez Co., a subsidiary of the General Asphalt Co. Most of the output is exported to the United States.

Asphalt exported from Venezuela, 1906–1918.

Year.	Quantity (short tons).	Value.	Year.	Quantity (short tons).	Value.
1906	24,783	$98,250	1913	63,884	$400,000
1907	42,153	167,938	1914	49,941	.....
1908	35,324	141,912	1915	31,949	.....
1909	41,767	180,061	1916	49,176	.....
1910	35,717	151,000	1917	54,410	.....
1911	56,183	238,000	1918	47,314	.....
1912	73,780	312,000			

EUROPE.

AUSTRIA-HUNGARY.

Prior to the war a large quantity of ozokerite was produced from rocks of Miocene age in the Carpathian Mountains of Galicia and shipped to various parts of the world. No data are available concerning the asphalt and ozokerite industries of Austria-Hungary during the years succeeding 1912.

Asphalt produced in Austria-Hungary, 1906–1912.

Year.	Quantity (metric tons).	Value.	Year.	Quantity (metric tons).	Value.
1906	9,646	$778,781	1910	8,228	$702,022
1907	10,283	727,892	1911	a 7,541	652,603
1908	11,103	768,162	1912	a 10,377	664,778
1909	10,142	663,246			

a Includes ozokerite.

FRANCE.

Asphalt produced in France, 1906–1912.

Year.	Quantity (metric tons).	Value.	Year.	Quantity (metric tons).	Value.
1906	196,321	$345,599	1910	169,722	$277,210
1907	177,026	330,065	1911	169,651	261,743
1908	171,111	264,188	1912	311,763	393,994
1909	169,008	269,161			

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GERMANY.

Asphalt produced in Germany, 1906–1912.

Year.	Quantity (metric tons).	Value.	Year.	Quantity (metric tons).	Value.
1906	117,380	$268,631	1910	81,186	$152,565
1907	126,614	264,494	1911	81,880	154,938
1908	88,985	188,334	1912	96,117	200,743
1909	77,516	176,897			

ITALY.

Asphalt produced in Italy, 1906–1916.

Year.	Quantity (metric tons).	Value.	Year.	Quantity (metric tons).	Value.
1906	131,363	$349,926	1912	181,947	$581,383
1907	161,596	442,014	1913	171,096	521,398
1908	134,657	368,306	1914	119,853	400,164
1909	111,911	305,159	1915	47,657	184,621
1910	162,626	452,911	1916	16,825	.....
1911	188,629	591,550			

RUSSIA.

Asphalt and allied substances produced in Russia, 1906–1910.

Year.	Quantity (metric tons).	Value.	Year.	Quantity (metric tons).	Value.
1906	11,355	$110,294	1909	2,418	$4,599
1907	12,806	101,705	1910	24,988	176,518
1908	22,644	491,302			

SPAIN.

Asphalt produced in Spain, 1906–1916.

Year.	Quantity (metric tons).	Value.	Year.	Quantity (metric tons).	Value.
1906	7,790	$17,130	1912	5,387	$13,003
1907	8,216	16,001	1913	b 5,582	13,402
1908	12,370	24,084	1914	5,765	13,847
1909	5,282	10,282	1915	4,521	10,706
1910	6,416	18,308	1916	7,134	.....
1911	a 3,741	8,754			

a Figures for 1911 do not include 7,165 tons of bituminous rock for which no value was reported.
b Figures for 1913 do not include 5,112 tons of bituminous rock, valued at $5,833.

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ASIA.

JAPAN.

Asphalt produced in Japan, 1906–1914.

Year.	Quantity (metric tons).	Value.	Year.	Quantity (metric tons).	Value.
1906	39	$3,572	1911	1,260	$13,728
1907	535	5,436	1912	2,902	32,518
1908	2,404	25,564	1913	2,260	27,242
1909	4,186	45,205	1914	2,006	25,836
1910	477	29,004			

TURKEY.

Although bitumen from the Dead Sea region in Palestine was probably used by the Assyrians and Babylonians in the construction of their palaces the deposits have not been used commercially for centuries. Bituminous cements have been identified in the ancient walls of the temple of Babylon, and there are ancient cisterns in Syria lined with bitumen that are still water-tight. The bituminous material in the Dead Sea region is said to be well adapted for road construction, and if it could be produced and used on the roads in the Near East, where because of climatic conditions and the narrow wheels of vehicles the highway problem is difficult to solve, transportation facilities could be improved.

STREET AND ALLEY PAVING IN THE UNITED STATES.

The following statistics collected by Engineering and Contracting [1] show the status of street and alley improvement in 185 typical municipalities in the United States in 1918 and "indicate that American cities have much work to do before they have a 100 per cent paved street mileage":

Paved and unpaved streets in 185 cities in the United States in 1918.

State and city.	Total miles of streets.	Total miles of alleys.	Miles of paved streets.	Miles of paved alleys.
California:				
Alameda	70.0	0.2	65.0	0.1
Bakersfield	86.0	33.0	17.2	1.4
Long Beach	208.0	100.0	52.0	20.0
Los Angeles	2,624.0	.....	465.0	16.6
Oakland	543.7	5.0	395.4	1.0
Pomona	123.0	.....	24.4	.3
Redlands	150.0	20.0	126.0	2.0
Riverside	200.0	.....	90.7	.5
San Francisco	[a] 825.0	.....	[a] 495.0	.....
Santa Barbara	80.0	2.0	25.0	.2
Colorado:				
Boulder	61.0	28.8	17.6	.2
Grand Junction	40.0	20.0	3.0	1.0
Connecticut:				
Bridgeport	192.0	.....	109.9	.....
Hartford	160.0	.....	15.0	.....
Wallingford	33.9	.....	9.8	.....
District of Columbia:				
Washington	638.1	.....	356.0	150.0

[a] Includes alleys.

[1] Engineering and Contracting, vol. 49, No. 18, p. 426, May 1, 1918.

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Paved and unpaved streets in 185 cities in the United States in 1918—Continued.

State and city.	Total miles of streets.	Total miles of alleys.	Miles of paved streets.	Miles of paved alleys.
Florida:				
Tallahassee	30.0		4.0	
Georgia:				
Brunswick	77.0	15.0	27.0	
Savannah	110.0	80.0	53.0	
Idaho:				
Pocatello	62.0	30.0	22.0	0.2
Illinois:				
Belleville	80.0	36.0	38.0	
Cairo	34.4	2.5	23.0	
Canton	48.0	27.0	15.0	2.0
Chicago	3,248.8	1,699.5	2,175.5	270.6
East St. Louis	177.0	99.8	59.0	.6
Galesburg	108.0		32.1	
Granite	35.0	20.0	12.0	
Kankakee	61.0	22.0	35.1	.5
La Salle	26.5	22.0	16.0	7.0
Moline	85.4	31.9	43.7	2.1
Murphysboro	35.0	10.0	15.0	
Oak Park	98.2	45.6	82.3	2.0
Quincy	108.0	27.0	41.2	5.0
Springfield	167.3	154.7	76.0	5.0
Taylorsville	35.3	27.3	10.8	.6
Indiana:				
Elkhart	115.0	100.0	23.8	1.5
Frankfort	48.8	32.7	28.9	1.2
Fort Wayne	214.0	150.0	104.0	7.0
Huntington	51.0	42.0	29.0	1.1
Lafayette	89.0	84.0	55.7	13.0
Richmond	69.2		34.4	
South Bend	217.3	200.0	75.1	5.0
Terre Haute	200.0	200.0	56.0	5.0
Iowa:				
Boone	80.0	40.0	14.5	.5
Cedar Rapids	172.0	98.0	66.8	3.0
Creston	65.0	20.0	14.5	1.0
Davenport	173.0	62.0	80.0	15.0
Dubuque	131.0	34.0	55.0	10.4
Grinnell	36.9		13.0	
Oelwein	33.0	18.0	9.0	.6
Oskaloosa	45.0	20.0	13.0	1.0
Sioux City	300.0	200.0	90.0	10.0
Waterloo	58.0		20.7	2.8
Webster City	30.0	24.0	12.0	2.0
Kansas:				
Coffeyville	58.0	28.0	28.0	2.0
Independence	62.8	28.5	29.7	5.5
Leavenworth	100.0	50.0	32.0	3.0
Manhattan	50.0	24.0	22.0	.1
Wellington	60.0	15.0	15.0	1.0
Wichita	300.0	250.0	70.0	5.0
Kentucky:				
Ashland	38.4	8.4	28.0	2.8
Louisville	339.3		238.7	
Louisiana:				
New Orleans	750.0	31.0	350.0	1.7
Shreveport	153.0	71.0	46.0	3.0
Maine:				
Portland	156.2		46.7	
Maryland:				
Cumberland	40.0	26.0	22.0	2.0
Massachusetts:				
Amherst	88.0		6.0	
Andover	175.0	1.0		
Arlington	65.4		18.3	
Beverly	71.0	17.0	15.0	
Boston	595.3	5.8	555.2	5.3
Brockton	131.5		44.0	
Brookline	75.0		65.0	
Fall River	155.4		41.8	
Fitchburg	141.2		28.3	
Haverhill	215.5	4.4	59.4	.2
Lawrence	108.0	10.0	41.0	
Lowell	217.0		71.0	
Maynard	25.0	2.0	15.0	.2
Medford	92.0		52.0	
Newton	225.0		94.0	
Saugus	75.0		1.2	
Waltham	96.4		39.6	
Watertown	57.3		38.3	
Westfield	102.0	2.0	12.8	
Worcester	312.0	6.2	117.7	.8

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Paved and unpaved streets in 185 cities in the United States in 1918—Continued.

State and city.	Total miles of streets.	Total miles of alleys.	Miles of paved streets.	Miles of paved alleys.
Michigan:				
Battle Creek	110.0	5.0	21.0	.....
Cadillac	58.0	21.0	18.0	0.7
Detroit	836.0	700.0	634.0	90.0
Flint	243.0	.....	42.3	.....
Grand Rapids	317.7	195.0	63.3	2.9
Kalamazoo	86.0	4.0	17.7	1.0
Pontiac	50.0	5.0	1.5	.....
Three Rivers	125.0	6.5	30.0	.5
Minnesota:				
Albert Lea	30.5	10.0	3.0	.5
Austin	43.5	8.6	4.2	.5
Cloquet	36.0	7.0	1.0	.....
Duluth	1,100.0	900.0	86.8	3.5
Mankato	43.0	21.0	9.5	2.0
Minneapolis	881.0	290.0	175.0	27.0
Owatonna	46.7	8.8	1.5	.3
Virginia	22.0	12.0	13.7	.5
Mississippi:				
Vicksburg	60.0	9.0	13.0	.....
Missouri:				
Cape Girardeau	39.0	19.0	15.0	.2
Columbia	59.5	8.9	26.4	.5
Hannibal	.....	.....	9.2	1.5
Kansas City	1,100.0	200.0	500.0	50.0
Springfield	145.0	97.0	56.4	3.0
Montana:				
Billings	63.2	29.8	9.5	1.0
Bozeman	42.0	35.0	9.0	.3
Butte	97.4	49.1	8.2	1.3
Great Falls	112.0	49.5	17.5	3.5
Nebraska:				
Fairbury	22.0	10.0	1.0	.....
Fremont	60.0	11.5	10.5	.7
Lincoln	205.0	95.0	76.9	6.3
New Hampshire:				
Concord	180.0	.....	15.0	.....
Keene	43.7	.....	10.1	.....
New Jersey:				
Camden	173.0	.....	86.8	.....
East Orange	72.0	.....	65.0	.....
Irvington	55.0	.....	18.0	.....
Montclair	84.5	.....	14.0	.....
Morristown	22.0	.5	15.0	.....
North Plainfield	18.5	.....	12.0	.....
Passaic	63.8	.....	41.1	.....
Paterson	207.0	1.0	110.3	1.0
Plainfield	83.0	1.0	66.6	.5
South Orange	30.0	.....	26.0	.....
New York:				
Auburn	87.3	2.0	66.0	.3
Binghamton	98.0	1.0	30.3	.5
Buffalo	631.0	7.2	424.2	4.6
Gloversville	52.5	.....	11.7	.....
Jamestown	341.6	4.7	119.3	1.2
Johnstown	48.0	.....	11.0	.....
Kingston	73.9	.....	73.9	.....
Mount Vernon	88.0	.....	68.0	.....
Niagara Falls	135.0	38.0	51.0	3.0
Norwich	19.0	.....	6.9	.....
Ogdensburg	36.0	3.0	26.0	.7
Olean	52.0	.....	15.0	.....
Oneonta	35.6	.....	6.0	.....
Oswego	84.6	.....	15.3	.....
Rochester	a401.0	.....	a 282.0	.....
Schenectady	130.0	2.2	79.6	.....
Syracuse	280.0	.5	110.0	.2
Utica	a131.3	.....	a 74.7	.....
North Carolina:				
Asheville	75.0	5.0	50.0	1.0
Greensboro	58.6	.....	23.5	.....
North Dakota:				
Devils Lake	15.0	6.0	.....	.....
Ohio:				
Canton	200.0	200.0	67.5	.....
Cincinnati	a960.0	.....	a 615.0	.....
Cleveland	a916.3	.....	a 601.8	.....
Conneaut	50.0	4.0	10.0	.....
Defiance	75.0	60.0	12.0	3.0

a Includes alleys.

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Paved and unpaved streets in 185 cities in the United States in 1918—Continued.

State and city.	Total miles of streets.	Total miles of alleys.	Miles of paved streets.	Miles of paved alleys.
Ohio—Continued.				
Fremont	49.0	8.0	16.0	1.0
Lakewood	79.0	1.0	60.0	.....
Lima	110.0	.....	45.0	.....
Lorain	91.0	60.0	28.0	1.0
Mansfield	73.0	30.0	40.0	2.0
Marietta	45.5	40.0	28.0	4.0
Sandusky	86.0	10.0	30.5	1.0
Tiffin	40.0	25.0	27.0	1.5
Toledo	450.0	192.0	242.0	10.0
Warren	95.5	2.5	36.5	.....
Zanesville	78.0	78.0	34.3	6.0
Oklahoma:				
Durant	35.0	35.0	5.0	.....
El Reno	30.0	10.0	12.0	.5
Oregon:				
Eugene	51.0	15.0	39.0	5.7
Medford	60.0	.....	20.0	.....
Portland	1,350.0	.....	438.0	.....
Pennsylvania:				
Allentown	a110.0	.....	a40.4	.....
Altoona	104.0	48.5	49.0	4.3
Bangor	20.0	10.0	14.0	.....
Bradford	24.5	.5	16.3	.2
Carlisle	25.0	20.0	16.7	5.0
Carnegie	20.0	9.0	13.0	1.2
Coatesville	14.5	8.8	7.0	.....
Dubois	33.0	37.0	7.0	1.0
Greensburg	28.3	16.3	20.6	2.6
Harrisburg	a118.8	.....	a35.0	.....
Lebanon	34.4	14.8	3.8	.3
Norristown	46.6	9.0	28.8	9.0
Oil City	48.0	14.0	22.0	2.0
Rankin	9.0	4.0	5.0	.7
Reading	90.0	.....	66.0	.....

a Includes alleys.

PRODUCERS.

The following operators reported to the United States Geological Survey that they produced asphaltic material from crude petroleum in the United States in 1918:

Asphaltum & Oil Refining Co., Los Angeles, Calif.
Atlantic Refining Co., 3144 Passyunk Avenue, Philadelphia, Pa.
California Fresno Oil Co., Fresno, Calif.
California Oil & Asphalt Co., 304–307 Grosse Building, Los Angeles, Calif.
Central Refining Co., Lawrenceville, Ill.
Craig Oil Co., Toledo, Ohio.
Fairchild-Gilmore-Wilton Co., 396 Pacific Electric Building, Los Angeles, Calif.
Freeport & Mexican Fuel Oil Corporation, 120 Broadway, New York, N. Y.
Gulf Refining Co., Frick Building Annex, Pittsburgh, Pa.
Hercules Oil Refining Co., 396 Pacific Building, Los Angeles, Calif.
Indian Refining Co., 44 Whitehall Street, New York, N. Y.
King Refining Co., 2[illegible]5 Holbrook Building, San Francisco, Calif.
Magnolia Petroleum Co., Box 1667, Dallas, Tex.
Paraffine Co. (Inc.), Emeryville, Calif.
Pierce Oil Corporation, 25 Broad Street, New York, N. Y.
Pine Island Refining Co., Shreveport, La.
Pioneer Asphalt Co., Lawrenceville, Ill.
Pioneer Paper Co., 251 South Los Angeles Street, Los Angeles, Calif.
Producers Refining Co., Bakersfield, Calif.
Prudential Oil Corporation, 17 Battery Place, New York, N. Y.
Seaside Oil Co., Summerland, Calif.
Shell Co. of California, Security Building, San Francisco, Calif.
Standard Asphalt & Refining Co., 208 La Salle Street, Chicago, Ill.
Standard Oil Co. of California, 200 Bush Street, San Francisco, Calif.
Standard Oil Co. of Indiana, 910 South Michigan Avenue, Chicago, Ill.

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Standard Oil Co. of Louisiana, Baton Rouge, La.
Standard Oil Co. of New Jersey, 26 Broadway, New York, N. Y.
Texas Co., Houston, Tex.
Turner Oil Co., 1006 California Building, Los Angeles, Calif.
Union Oil Co. of California, 287 Mills Building, San Francisco, Calif.
United States Asphalt Refining Co., 90 West Street, New York, N. Y.
Warner Quinlan Asphalt Co., 79 Wall Street, New York, N. Y.

Native asphalt and related bitumens were produced commercially in this country in 1918 by the following companies:

American Asphalt Association, 918 Wainwright Building, St. Louis, Mo.
American Chemical & Ozokerite Co., 208 Kearns Building, Salt Lake City, Utah.
City Street Improvement Co., Seventeenth and Harrison streets, San Francisco, Calif.
Consolidated Bituminous Rock Co., 511 Nevada Building, San Francisco, Calif.
Fort Smith Asphalt Co., Fort Smith, Ark.
Gilson Asphaltum Co., 1900 Land Title Building, Philadelphia, Pa.
Kentucky Rock Asphalt Co., 712 Paul Jones Building, Louisville, Ky.
Raven Mining Co., Marquette Building, Chicago, Ill.
Sattler & Stevens, Carpinteria, Calif.
Uvalde Rock Asphalt Co., San Antonio, Tex.

SELECTED BIBLIOGRAPHY.

All the publications on petroleum and most of those on asphalt and related bitumens in the following bibliography were issued by the United States Geological Survey. The bulletins and the reports entitled "Mineral Resources of the United States" that are in stock may be obtained free by applying to the Director, United States Geological Survey, Washington, D. C. The folios of the Geologic Atlas are sold by the Survey, and many of the other reports that are no longer available for free distribution may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C. Most of the publications in this list may be consulted in the public libraries of the larger cities.

PETROLEUM.[1]

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MINERAL WATERS.

By ARTHUR J. ELLIS.

SCOPE OF REPORT.

The term mineral water as it is used in this report applies to water that is bottled and sold in its natural state or only slightly altered from its natural state. It includes (*a*) natural carbonated waters that have lost part of their carbon dioxide; (*b*) natural waters that have been artificially carbonated; and (*c*) waters from which iron has been removed. It does not include artificial waters or natural waters that have been essentially modified in chemical character. Waters that have been flavored, concentrated, fortified, diluted, or otherwise radically altered are therefore not included.

The statistics in this report refer only to domestic mineral waters that have been sold, imports being excepted. Water that is given away, including water furnished free for drinking or bathing to guests at hotels or to patients at sanitariums, has been omitted even where there are data available to show the quantity of water so used. Hence, as actual sales fall far short of the total quantity used, particularly of such waters as are drunk at fashionable resorts for their medicinal value, the totals do not represent the full magnitude of the trade.

Three uses of mineral waters are recognized in this report—table use, medicinal use, and use in the manufacture of soft drinks.

Distinction for statistical purposes between table and medicinal waters is entirely arbitrary. Most table waters are clear, sparkling, and without distinct mineral taste or odor. Some table waters are, however, more strongly mineralized than some medicinal waters, and many medicinal waters contain less mineral matter than certain city supplies. The distinction in this report between table waters and medicinal waters is based on the reports furnished by the owners and operators of springs, which state the uses for which the waters are sold. An operator's report is, in turn, based on his knowledge of the uses to which his customers put the water. The reports show that as many as 90 waters are sold in the United States for both table and medicinal purposes, and that 29 waters are sold for table use, medicinal use, and use in the manufacture of soft drinks. It is apparent, therefore, that although this classification is useful for statistical purposes, it does not correspond to fundamental differences in composition in the waters themselves.

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USES OF MINERAL WATERS.

The figures in the following table are grouped according to uses of the water. As shown in this table 90 waters are sold for both medicinal and table use and might properly be classed as table waters. These, together with the 323 waters that are sold exclusively for table use, make in all 413 table waters, as compared with 140 waters sold exclusively for medicinal use.

Number of springs supplying water of each class in 1918.

State.	Number of mineral waters.[a]	Sold for table use only.	Sold for medicinal use only.	Sold for both table and medicinal uses.	Used for soft drinks.	Used for soft drinks only.	Used for soft drinks and sold for table purposes.	Used for soft drinks and sold for medicinal purposes.	Used for soft drinks and sold for table and medicinal purposes.
Alabama	7	.....	6	1	.....	.....	.....	.....	.....
Arkansas	8	1	5	2	1	.....	.....	.....	1
California	38	20	12	6	9	.....	6	.....	3
Colorado	10	4	3	3	5	.....	2	1	2
Connecticut	27	22	1	2	12	2	9	.....	1
Delaware	1	1	.....	.....	.....	.....	.....	.....	.....
District of Columbia	1	1	.....	.....	.....	.....	.....	.....	.....
Florida	5	1	3	1	.....	.....	.....	.....	.....
Georgia	10	5	3	2	.....	.....	.....	.....	.....
Illinois	13	8	3	2	3	.....	.....	.....	3
Indiana	10	2	5	3	.....	.....	.....	.....	.....
Iowa	4	2	1	1	3	.....	2	.....	1
Kansas	9	4	3	2	1	.....	1	.....	.....
Kentucky	11	3	5	3	2	.....	1	.....	1
Louisiana	1	.....	1	.....	.....	.....	.....	.....	.....
Maine	21	12	2	7	4	.....	3	.....	1
Maryland	8	6	2	.....	3	.....	2	1	.....
Massachusetts	43	34	1	6	16	2	9	1	4
Michigan	9	7	.....	2	1	.....	.....	.....	1
Minnesota	16	13	.....	3	11	.....	10	.....	1
Mississippi	7	.....	7	.....	.....	.....	.....	.....	.....
Missouri	26	17	3	6	.....	.....	.....	.....	.....
Montana	3	2	.....	1	.....	.....	.....	.....	.....
Nebraska	3	1	1	.....	1	1	.....	.....	.....
Nevada	1	1	.....	.....	.....	.....	.....	.....	.....
New Hampshire	3	3	.....	.....	3	.....	3	.....	.....
New Jersey	13	12	1	.....	3	.....	3	.....	.....
New Mexico	1	1	.....	.....	.....	.....	.....	.....	.....
New York	50	38	8	3	5	1	3	1	.....
North Carolina	10	4	4	2	.....	.....	.....	.....	.....
North Dakota	3	3	.....	.....	1	.....	1	.....	.....
Ohio	21	13	3	2	2	.....	2	.....	.....
Oklahoma	8	3	4	1	1	.....	1	.....	.....
Oregon	4	4	.....	1	2	.....	1	.....	1
Pennsylvania	30	19	4	6	7	1	4	1	1
Rhode Island	6	6	.....	.....	6	.....	6	.....	.....
South Carolina	7	1	4	2	1	.....	1	.....	.....
South Dakota	3	2	.....	1	2	.....	1	.....	1
Tennessee	13	3	7	3	.....	.....	.....	.....	.....
Texas	18	.....	18	.....	1	1	.....	.....	.....
Vermont	4	2	.....	2	1	.....	1	.....	.....
Virginia	35	12	14	8	3	1	1	.....	1
Washington	1	1	.....	.....	.....	.....	.....	.....	.....
West Virginia	8	3	4	1	1	.....	1	.....	.....
Wisconsin	32	19	1	4	21	7	9	.....	5
Wyoming	4	2	1	1	1	.....	.....	.....	1
	569	323	140	90	133	16	83	5	29

[a] Equivalent to the number of active springs.

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cation of wells see table for each State in text.

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SOURCES OF MINERAL WATERS.

The mineral waters sold in the United States are for the most part derived from natural springs. Many, however, are obtained from wells, and some from streams. No distinction is made in this report between mineral water flowing or pumped from a natural spring and that flowing or pumped from a dug, bored, driven, or drilled well, but wherever the available information permits the sources are given their proper designations in the tables as springs or wells.

The geographic distribution of the sources of mineral waters sold in the United States in 1918 is shown on Plate V. The springs and wells, the operators of which cooperate with the Geological Survey by furnishing reports on the volume of business, are shown as accurately as possible.

MINERAL-WATER TRADE IN 1918.

OUTPUT AND VALUE.

The number of mineral springs utilized commercially was smaller in 1918 than in 1917, as were also the quantity and value of the water sold from them.

Wisconsin ranked first and New York second in quantity and value of mineral waters sold for all purposes and were followed in order by California, Maine, Indiana, and Virginia. Massachusetts ranked first in the consumption of mineral waters for soft drinks; Indiana was first in value of medicinal waters, and California and New York were in second and third place, respectively. In value of table waters, Wisconsin, in first place, and New York, in second place, were followed in order by California, Maine, Ohio, Michigan, Virginia, and Massachusetts. More than 25 springs were active in each of 8 States, more than 1,000,000 gallons of mineral water was sold in each of 13 States, and the value of the water sold amounted to more than $100,000 in each of 12 States.

Sales were reported from 569 springs in 1918, as compared with 717 springs in 1917. No reports of mineral-water sales were received from Arizona, Idaho, or Utah, and less than three commercially productive springs each were reported from Delaware, District of Columbia, Louisiana, Nevada, New Mexico, and Washington; three or more springs were productive in every other State in the Union. Sales exceeded 5,000,000 gallons in New York and Wisconsin, and the total value of the product was more than $1,000,000 in Wisconsin and more than $500,000 in New York.

As shown in the following table, 90 per cent of all the mineral waters sold in the United States in 1918 came from 21 States. All other States than those mentioned in the following table furnished less than 1 per cent each.

Not all of this water was consumed in the United States, a considerable quantity being exported, but no separate statistics of exports are available.

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Mineral water sold in the leading States and their respective percentages of total sold in the United States in 1918.

State.	Quantity.	Approximate percentage of total.	State.	Quantity.	Approximate percentage of total.
	Gallons.			*Gallons.*	
Wisconsin	6,630,725	16	Tennessee	990,027	2
New York	5,887,746	14	Illinois	921,953	2
Ohio	2,771,485	7	Arkansas	863,142	2
California	2,399,144	6	Maine	829,338	2
Minnesota	2,248,731	6	Indiana	555,076	2
Massachusetts	1,999,592	5	Texas	544,183	2
Virginia	1,745,105	4	North Dakota	530,000	1
Pennsylvania	1,400,456	3	South Dakota	454,865	1
Connecticut	1,364,443	3		36,744,192	90
Michigan	1,216,882	3			
Oklahoma	1,166,485	3	All other States	3,965,530	10
New Jersey	1,134,848	3			
Maryland	1,089,966	3		40,709,722	100

Mineral waters sold in the United States in 1917 and 1918.

State.	Commercial springs.	Quantity sold.	Average price per gallon.	Value of medicinal waters.	Value of table waters.	Total value.
1917.		*Gallons.*	*Cents.*			
Alabama	13	56,270	10	$3,437	$2,072	$5,509
Arkansas	8	1,020,463	8	61,742	16,399	78,141
California	52	2,566,491	18	127,593	327,767	455,360
Colorado	12	442,815	15	25,679	39,490	65,169
Connecticut	31	1,964,096	5	3,127	100,851	103,978
Florida	7	142,030	7	5,818	4,032	9,850
Georgia	11	411,127	9	6,471	30,970	37,441
Illinois	16	1,370,461	5	1,471	64,571	66,042
Indiana	16	521,758	29	143,285	9,184	152,469
Iowa	4	99,103	12	4,375	7,750	12,125
Kansas	11	289,493	23	60,779	6,997	67,776
Kentucky	13	301,748	13	24,396	15,793	40,189
Louisiana	4	270,000	7	6,990	12,500	19,490
Maine	24	1,014,084	34	86,570	257,017	343,587
Maryland	7	1,036,045	8	1,409	85,529	86,938
Massachusetts	48	2,908,638	5	7,334	131,741	139,075
Michigan	12	1,069,164	10	500	105,141	105,641
Minnesota	17	3,004,546	4	32,528	77,436	109,964
Mississippi	12	197,555	25	49,138	648	49,786
Missouri	33	401,776	14	43,883	13,292	57,175
Montana	4	211,133	5	500	9,070	9,570
New Hampshire	7	105,181	7	158	6,817	6,975
New Jersey	14	1,283,157	9	7,751	107,437	115,188
New Mexico	3	48,325	5	40	2,290	2,330
New York	65	7,819,314	7	173,187	389,687	562,874
North Carolina	18	103,659	15	12,248	3,416	15,664
North Dakota	3	556,000	2	.....	12,837	12,837
Ohio	31	3,113,093	4	6,540	130,170	136,710
Oklahoma	11	852,381	3	2,650	24,347	26,997
Oregon	5	13,741	21	579	2,263	2,842
Pennsylvania	41	1,603,090	9	18,206	128,815	147,021
Rhode Island	6	368,976	7	.....	24,975	24,975
South Carolina	7	289,094	16	44,244	1,485	45,729
South Dakota	3	443,167	3	42	13,503	13,545
Tennessee	19	758,193	6	26,781	20,581	47,362
Texas	27	541,178	13	69,915	2,260	72,175
Vermont	4	94,500	19	2,000	15,705	17,705
Virginia	41	2,518,050	9	108,677	129,111	237,788
Washington	4	155,265	5	540	6,725	7,265
West Virginia	7	156,267	24	17,870	19,659	37,529
Wisconsin	36	6,296,634	22	64,140	1,298,358	1,362,498
Wyoming	4	53,726	15	2,850	5,040	7,890
Other States[a]	6	312,632	4	20	12,516	12,536
	717	46,784,419	11	1,255,463	3,676,247	4,931,710

[a] Includes Delaware, District of Columbia, Nebraska, and Nevada.

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Mineral waters sold in the United States in 1917 and 1918—Continued.

State.	Commercial springs.	Quantity sold.	Average price per gallon.	Value of medicinal waters.	Value of table waters.	Total value.
1918.		*Gallons.*	*Cents.*			
Alabama	7	6,315	29	$1,688	$120	$1,808
Arkansas	8	863,142	8	62,031	8,595	70,626
California	38	2,399,144	18	140,808	292,202	433,010
Colorado	10	319,542	25	34,284	47,083	81,367
Connecticut	27	1,364,443	5	12,073	60,454	72,527
Florida	5	164,630	6	4,105	8,778	12,883
Georgia	10	314,388	9	5,940	21,870	27,810
Illinois	13	921,953	5	1,337	42,111	43,448
Indiana	10	555,076	32	161,964	17,467	179,431
Iowa	4	87,703	4	2,479	1,458	3,937
Kansas	9	403,862	19	56,994	18,365	75,359
Kentucky	11	255,852	16	29,800	12,197	41,997
Maine	21	829,338	32	67,670	198,498	266,168
Maryland	8	1,089,966	9	3,000	97,575	100,575
Massachusetts	43	1,999,592	6	6,034	119,174	125,208
Michigan	9	1,216,882	11	783	128,809	129,592
Minnesota	16	2,248,731	4	183	98,976	99,159
Mississippi	7	175,533	27	47,539	.....	47,539
Missouri	26	306,299	13	30,137	8,341	38,478
Montana	3	193,557	5	26	8,886	8,912
Nebraska	3	1,060	14	15	140	155
New Hampshire	3	182,326	5	.....	8,256	8,256
New Jersey	13	1,134,848	10	25	110,125	110,150
New York	50	5,887,746	10	135,437	431,473	566,910
North Carolina	10	65,422	12	5,382	2,792	8,174
North Dakota	3	530,000	3	.....	13,700	13,700
Ohio	24	2,771,485	5	6,151	144,560	150,711
Oklahoma	8	1,166,485	2	4,000	16,249	20,249
Oregon	4	13,550	13	125	1,700	1,825
Pennsylvania	30	1,400,456	9	10,896	112,540	123,436
Rhode Island	6	365,705	8	.....	30,729	30,729
South Carolina	7	279,300	18	48,988	2,210	51,198
South Dakota	3	454,865	4	4	17,265	17,269
Tennessee	13	990,027	5	10,413	42,954	53,367
Texas	18	544,183	15	80,553	.....	80,553
Vermont	4	95,700	18	8,300	8,790	17,090
Virginia	35	1,745,105	10	48,379	125,533	173,912
West Virginia	8	201,883	11	8,831	23,214	32,045
Wisconsin	32	6,630,725	18	39,737	1,153,608	1,193,345
Wyoming	4	41,335	13	1,525	3,988	5,513
Other States [a]	6	391,548	4	1,500	13,080	14,580
	569	40,709,722	11	1,079,136	3,453,865	4,533,001

[a] Includes Delaware, District of Columbia, Louisiana, Nevada, New Mexico, and Washington.

CONDITION OF TRADE.

The total quantity of mineral waters sold in 1918 was less than in any year since 1903 and the total value was less than in any year since 1896. The decrease in sales of mineral waters during the war period is shown in the following table:

Mineral waters sold in the United States, 1913–1918.

Year.	Commercial springs.	Quantity sold.	Value.	Average price per gallon.
		Gallons.		*Cents.*
1913	838	57,867,399	$5,681,391	10
1914	829	54,358,466	4,892,328	9
1915	812	52,113,503	5,138,794	10
1916	802	55,928,461	5,735,035	10
1917	717	46,784,419	4,931,710	11
1918	569	40,709,722	4,533,001	11

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Comparative production of mineral waters, 1917 and 1918.

State.	1917			1918			Increase or decrease in number of springs.	Increase or decrease in quantity sold.		Increase or decrease in value of product.	
	Commercial springs.	Quantity sold.	Value.	Commercial springs.	Quantity sold.	Value.		Gallons.	Per cent.		Per cent.
		Gallons.			Gallons.						
Alabama	13	56,270	$5,509	7	6,315	$1,808	− 6	− 49,955	−89	− $3,701	−67
Arkansas	8	1,020,463	78,141	8	863,142	70,626	0	− 157,321	−15	− 7,515	−10
California	52	2,566,491	455,360	38	2,399,144	433,010	− 14	− 167,347	− 7	− 22,350	− 5
Colorado	12	442,815	65,169	10	319,542	81,367	− 2	− 123,273	−28	+ 16,198	+25
Connecticut	31	1,964,096	103,978	27	1,364,443	72,527	− 4	− 599,653	−31	− 31,451	−30
Delaware	1	(a)	(a)	1	(a)	(a)	0	(a)	(a)	(a)	(a)
District of Columbia	1	(a)	(a)	1	(a)	(a)	0	(a)	(a)	(a)	(a)
Florida	7	142,030	9,850	5	164,630	12,883	− 2	+ 22,600	+16	+ 3,033	+31
Georgia	11	411,127	37,441	10	314,388	27,810	− 1	− 96,739	−24	− 9,631	−26
Illinois	16	1,370,461	66,042	13	921,953	43,448	− 3	− 448,508	−33	− 22,594	−34
Indiana	16	521,758	152,469	10	555,076	179,431	− 6	+ 33,318	+ 6	+ 26,962	+18
Iowa	4	99,103	12,125	4	87,703	3,937	0	− 11,400	−12	− 8,188	−68
Kansas	11	289,493	67,776	9	403,862	75,359	− 2	+ 114,369	+40	+ 7,583	+11
Kentucky	13	301,748	40,189	11	255,852	41,997	− 2	− 45,896	−15	+ 1,808	+ 4
Louisiana	4	270,000	19,490	1	(a)	(a)	− 3	(a)	(a)	(a)	(a)
Maine	24	1,014,084	343,587	21	829,338	266,168	− 3	− 184,746	−18	− 77,419	−23
Maryland	7	1,036,045	86,938	8	1,089,966	100,575	+ 1	+ 53,921	+ 5	+ 13,637	+16
Massachusetts	48	2,908,638	139,075	43	1,999,592	125,208	− 5	− 909,046	−31	− 13,867	−10
Michigan	12	1,089,164	105,641	9	1,216,882	129,592	− 3	+ 147,718	+14	+ 23,951	+23
Minnesota	17	3,004,546	109,964	16	2,248,731	99,159	− 1	− 755,815	−25	− 10,805	−10
Mississippi	12	197,555	49,786	7	175,533	47,539	− 5	− 22,022	−11	− 2,247	− 5
Missouri	33	401,776	57,175	26	306,299	38,478	− 7	− 95,477	−24	− 18,697	−33
Montana	4	211,133	9,570	3	193,557	8,912	− 1	− 17,576	− 8	− 658	− 7
Nebraska	2	(a)	(a)	3	1,080	155	+ 1	(a)	(a)	(a)	(a)
Nevada	2	(a)	(a)	1	(a)	(a)	− 1	(a)	(a)	(a)	(a)
New Hampshire	7	105,181	6,975	3	182,326	8,256	− 4	+ 77,145	+73	+ 1,281	+18
New Jersey	14	1,283,157	115,188	13	1,134,848	110,150	− 1	− 148,309	−12	− 5,038	− 4
New Mexico	3	48,325	2,330	1	(a)	(a)	− 2	(a)	(a)	(a)	(a)
New York	65	7,819,314	562,874	50	5,887,746	566,910	− 15	−1,931,568	−25	+ 4,036	+ .7
North Carolina	18	103,659	15,664	10	65,422	8,174	− 8	− 38,237	−37	− 7,490	−48
North Dakota	3	556,000	12,837	3	530,000	13,700	0	− 26,000	− 5	+ 863	+ 7
Ohio	31	3,113,093	136,710	24	2,771,485	159,711	− 7	− 341,608	−11	+ 14,001	+10
Oklahoma	11	852,381	26,997	8	1,166,485	20,249	− 3	+ 314,104	+37	− 6,748	−25
Oregon	5	13,741	2,842	4	13,550	1,825	− 1	− 191	− 1	− 1,017	−36
Pennsylvania	41	1,603,090	147,021	30	1,400,456	123,436	− 11	− 202,634	−13	− 23,585	−16
Rhode Island	6	368,976	24,975	6	365,705	30,729	0	− 3,271	− .9	+ 5,754	+23
South Carolina	7	289,094	45,729	7	279,300	51,198	0	− 9,794	− 3	+ 5,469	+12
South Dakota	3	443,167	13,545	3	454,865	17,269	0	+ 11,698	+ 3	+ 3,724	+27
Tennessee	19	758,193	47,362	13	990,027	53,367	− 6	+ 231,834	+31	+ 6,005	+13

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Texas	27	541,178	72,175	18	544,183	80,553	− 9	+ 3,005	+ .6	+ 8,378	+12
Vermont	4	94,500	17,705	4	95,700	17,090	0	+ 1,200	+ 1	− 615	− 3
Virginia	41	2,518,050	237,788	35	1,745,105	173,912	− 6	− 772,945	−31	− 63,876	−27
Washington	4	155,265	7,265	1	(a)	(a)	− 3	(a)	(a)	(a)	(a)
West Virginia	7	156,267	37,529	8	301,883	32,045	+ 1	+ 145,616	+93	− 5,484	−15
Wisconsin	36	6,296,634	1,362,498	32	6,630,725	1,193,345	− 4	+ 334,091	+ 5	−169,153	−12
Wyoming	4	53,726	7,890	4	41,335	5,513	0	− 12,391	−23	− 2,377	−30
Other States b	.....	312,632	12,536	.....	391,548	14,580	.....	− 393,594	−50	− 26,886	− −65
	717	46,784,419	4,931,710	569	40,709,722	4,533,001	−148	−6,074,607	−13	−398,709	− 8

a Included under "Other States."
b Includes in 1917 Delaware, District of Columbia, Nebraska, and Nevada; in 1918 ,Delaware, District of Columbia, Louisiana, Nevada New Mexico, and Washington.

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RANGE OF PRICE.

Effort has been made in compiling the following table, which gives the quantity and value of mineral water sold within certain ranges of price during 1917 and 1918, to eliminate freight and marketing charges and the value of returnable containers, and thus to give the net value of the waters at their sources.

Range of price per gallon of mineral water, 1917 and 1918.

Price per gallon (in cents).	Number of springs.	Quantity sold.	Value.	Percentage of number of springs.	Percentage of total quantity.	Percentage of total value.
1917.		*Gallons.*				
Not more than 2	28	3,319,063	$52,350	4	7	1
More than 2 and not more than 5	163	19,354,995	674,219	23	41	14
More than 5 and not more than 10	265	14,654,374	1,230,718	38	31	25
More than 10 and not more than 20	99	4,052,103	632,423	14	9	13
More than 20 and not more than 30	53	924,773	239,648	8	2	5
More than 30 and not more than 50	59	3,605,682	1,544,024	9	8	31
More than 50 and not more than 100	23	869,240	550,061	3	2	11
More than 100	7	4,189	8,267	1	0	0
	[a] 697	46,784,419	4,931,710	100	100	100
1918.						
Not more than 2	20	2,249,978	39,575	4	5.5	.9
More than 2 and not more than 5	115	12,240,608	459,269	21	30.1	10.0
More than 5 and not more than 10	222	17,248,591	1,390,842	40	42.3	31.0
More than 10 and not more than 20	89	4,507,057	681,890	16	11.1	15.0
More than 20 and not more than 30	38	518,147	134,732	7	1.3	3.0
More than 30 and not more than 50	36	3,095,801	1,189,595	7	7.6	26.1
More than 50 and not more than 100	25	701,049	467,502	4	1.7	10.3
More than 100	8	148,501	169,596	1	.4	3.7
	[b] 553	40,709,722	4,533,001	100	100.0	100.0

[a] Exclusive of 20 springs whose waters are used exclusively in the manufacture of soft drinks.
[b] Exclusive of 16 springs whose waters are used exclusively in the manufacture of soft drinks.

Practically four-fifths of the mineral waters was sold at prices ranging from half a cent to 10 cents a gallon during 1913, 1914, 1915, 1916, 1917, and 1918. The percentage sold for more than 30 cents a gallon was 9.7 per cent in 1918, as compared with 10 per cent in 1917. The water from 357 springs was sold for 10 cents or less a gallon, and the water from 8 springs was sold for more than $1 a gallon. The average price per gallon in 1918 was 11 cents.

SOFT DRINKS.

Returns show that the quantity of mineral water used in the manufacture of soft drinks in 1918 was more than in 1917. The gross distribution of the consumption during 1918 is indicated in the following table. Massachusetts heads the list with a consumption greater than 1,800,000 gallons and Wisconsin follows with nearly 1,500,000 gallons. In addition to Massachusetts and Wisconsin 12 States reported consumption exceeding 100,000 gallons each, and 17 other States reported a combined consumption of 705,837 gallons. This recorded consumption does not represent the total production of soft drinks in the United States, as most of them are compounded with municipal and private supplies not classified as mineral waters.

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Mineral waters used in the manufacture of soft drinks in 1918.

Rank.	State.	Quantity.	Rank.	State.	Quantity.
		Gallons.			*Gallons.*
1	Massachusetts	1,819,246	10	Iowa	215,000
2	Wisconsin	1,423,900	11	Colorado	176,831
3	Virginia	519,586	12	California	146,875
4	Pennsylvania	463,832	13	Ohio	145,000
5	New Hampshire	377,403	14	Maryland	119,642
6	South Carolina	300,000		Other States	705,837
7	Connecticut	278,663			
8	Minnesota	278,651			7,220,944
9	New York	250,478			

EXPORTS.

Large quantities of a few domestic waters are exported, but no statistics regarding such shipments are available. The quantity and the value of these waters are included in the statistics of production for the United States.

IMPORTS.

Until July 1, 1918, the statistics of imports of mineral waters, as reported by the Bureau of Foreign and Domestic Commerce, Department of Commerce, included artificial mineral waters and imitations of natural mineral waters. Figures relative exclusively to the imports of natural waters were not available. After July 1, 1918, records were kept of the imports of natural waters, and these are available for this report. Owing to this change in the records it is not practicable to make a direct comparison between the figures for the last half of 1918 and those for the first half and for preceding years.

The total imports of natural and artificial mineral waters entered for consumption in the period January to June, inclusive, 1918, amounted to 288,701 gallons, valued at points of shipment at $138,671 or an average of 48 cents a gallon. From July to December, inclusive, 1918, the imports for consumption of natural mineral waters exclusively amounted to 200,786 gallons, valued at points of shipment at $102,970, the average price per gallon being 51 cents. During the entire year 1918 there was imported for consumption in this country, 3,566,346 pounds of mineral salts, obtained by evaporation from natural mineral waters. These imports were valued at $10,231.

Mineral waters imported for consumption in the United States, 1914–1918.

Year.	Quantity.	Value.	Price per gallon.
	Gallons.		*Cents.*
1914	2,786,142	$857,707	31
1915	1,528,181	551,648	36
1916	1,553,199	624,302	40
1917	618,405	268,665	43
1918 (January to June	288,701	138,671	48
1918 (July to December	200,786	102,970	51

[a] Natural mineral waters exclusively. Figures for first half of 1918 and for all preceding years, include artificial mineral waters and imitation mineral waters, in addition to natural mineral waters.

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The following table shows the general imports by principal countries. The figures include both artificial mineral waters and imitations of minerals waters.

Mineral waters imported into the United States, by countries, in 1918.

Country.	Quantity (gallons).	Value.	Country.	Quantity (gallons).	Value.
France	560,058	$240,212	Mexico	9	$3
Italy	675	394	Cuba	99	42
Spain	2,970	1,445	Japan	2,661	460
England	18	9	Australia	12	15
Ireland	12	9			
Canada	366	165		566,880	242,754

"General imports" and "imports for consumption" for any period will differ to the extent that the value of entries for warehouse for the period differs from the value of withdrawals from warehouse for consumption. The term "entry for consumption" is the technical name of the import entry made at the customhouse and implies that the goods have been delivered into the custody of the importer and that the duties have been paid on the dutiable portion.

MINERAL-WATER TRADE BY STATES.[1]

ALABAMA.

Returns from Alabama indicate that the mineral-water trade in 1918 was about 89 per cent less than it was in 1917. The sales amounted to 6,315 gallons, and the value of the output was $1,808, the average price per gallon increasing from 10 cents to 29 cents. There was a considerable decrease in the value of the output of table waters, from $2,072 to $120. Three springs which were active in 1917 reported no sales for 1918; three from which no reports were received were omitted; and one which was idle in 1917 reported sales in 1918. Three resorts accommodating about 185 guests were maintained. No bathing establishments were maintained and no mineral waters were used in the manufacture of soft drinks.

Sources of mineral waters sold in Alabama in 1918.

Spring or well.	Location.			
	County.	Nearest post office.	Direction from post office.	Distance from post office.
				Miles.
Bladon Springs	Choctaw	Bladon Springs		
Bromberg Gulf Coast Lithia Springs.	Mobile	Bayou Labatre	West	1
Gordon Mineral Springs	Escambia	Canoe	West	½
Healing Springs	Washington	Healing Springs		
Luverne Mineral Springs	Crenshaw	Luverne		
Matchless Mineral Water Well	Butler	Greenville	Southeast	3
White Sulphur Well	Clarke	Jackson	Southeast	1

[1] The locations of the springs by States are shown on the map (Pl. V).

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ARKANSAS.

The sales of mineral waters in Arkansas during 1918 were 863,142 gallons, as reported from eight active springs, a decrease of more than 15 per cent from the output in 1917. The average price of the water remained the same, 8 cents, and the total value of the output amounted to $70,626, which was about 10 per cent less than the total value of sales in 1917. The sales of table waters showed a large falling off, from $16,399 to $8,595, and the sales of medicinal waters increased slightly.

One spring which was active in 1917 reported no sales in 1918; from two which reported in 1917 no figures were obtainable in 1918; two springs which reported no sales in 1917 were active in 1918; and one spring which did not report in 1917 reported sales in 1918.

About 62 guests, exclusive of Eureka (Springs) and Hot Springs, were accommodated, in addition to which 100,000 gallons of mineral water was used in the manufacture of soft drinks, as compared with 250,000 gallons used for this purpose in 1917.

Sources of mineral waters sold in Arkansas in 1918.

Spring or well.	Location.			
	County.	Nearest post office.	Direction from post office.	Distance from post office.
				Miles.
Chewaukla Mineral Springs	Garland	Hot Springs		
Crystal Lithox Spring	do	do		
De Soto Spring	do	do		
Happy Hollow Springs	do	do	Northeast	1
Mountain Valley Springs	do	Mountain Valley	West	1½
Oaklawn Mineral Well	do	Hot Springs	South	1
Ozarka Springs	Carroll	Eureka Springs	East	1½
Raleigh Springs	Pulaski	Little Rock	Southwest	2½

CALIFORNIA.

The output of mineral waters in California in 1918 showed a decrease of about 7 per cent in quantity and 5 per cent in value, as compared with the output in 1917.

The total quantity sold was 2,399,144 gallons. Medicinal waters sold for $140,808 and table waters for $292,202—a total of $433,010, the average price being 18 cents.

The output of one spring from which no report could be obtained has been estimated. The number of active springs was 38. Mineral-water baths were maintained at 13 springs, and 12 resorts, accommodating about 3,000 guests, were operated. In the manufacture of soft drinks, 146,875 gallons of mineral water was used.

Mineral waters sold in California, 1914–1918.

Year.	Commercial springs.	Quantity sold.	Value.	Average price per gallon.
		Gallons.		*Cents.*
1914	48	2,282,569	$497,923	22
1915	50	2,789,871	532,817	19
1916	55	2,651,471	503,775	19
1917	52	2,566,491	455,360	18
1918	38	2,399,144	433,010	18

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Sources of mineral waters sold in California in 1918.

Spring or well.	Location.			
	County.	Nearest post office.	Direction from post office.	Distance from post office.
				Miles.
Agua Caliente Springs	Sonoma	Agua Caliente		
Alhambra Springs	Contra Costa	Martinez	Southwest	6
Alma Spring	Santa Clara	Alma		1
Arrowhead Springs	San Bernardino	Arrowhead Springs		
Barcal Spring	Sonoma	Preston	Northeast	1
Bartlett Spring	Lake	Bartlett Springs		
Beulah Springs	Riverside	Arlington		
Bimini Hot Springs	Los Angeles	Los Angeles	West	3
Boyes Hot Springs	Sonoma	Boyes Springs		
Busch Springs	Mendocino	Potter Valley	Northwest	7½
Bythinia Well	Santa Barbara	Santa Barbara	West	4½
Castle Rock Mineral Springs	Shasta	Castella	East	1
Console Mineral Springs	Riverside	Riverside	do	12
Cooks Springs	Colusa	Leesville	Northwest	10
Crystal Spring	Los Angeles	Los Angeles	do	1½
Elliotta Springs	Riverside	Riverside	North	1½
Elysian Spring	Los Angeles	Los Angeles		
Grizzly Springs	Lake	Wilbur Springs	West	4½
Iaqua Medicinal Spring	Humbolt	Eureka		
Lepori Vichy Springs	Napa	Napa	Northeast	3½
McGlashan Mineral Spring	Placer	Truckee	South	5½
Magnesia	Sonoma	The Geysers		
Marin Mountain Spring	Marin	Sausalito		
Mok-Hill Mineral Spring	Calaveras	Mokelumne Hill	East	½
Napa Rock and Priest-Napa Soda Springs	Napa	Soda Valley[a]		
Napa Soda Springs	do	Napa Soda Springs		
Nuvida Springs	San Diego	La Presa[a]		
Polk Springs	Tehama	Butte Meadows	West	14
Pope Mineral Springs	Napa	Pope Valley	Southwest	6
Radium Sulphur Springs	Los Angeles	Los Angeles	Northwest	6
Richardson Springs	Butte	Chico	Northeast	12
Shanghai Spring	Marin	Sausalito	Northwest	3
Shasta Spring	Siskiyou	Shasta Springs		
Tamalpais Spring	Marin	San Rafael	Northwest	½
Tuscan Springs	Tehama	Tuscan		
Valley Springs	Calaveras	Valley Springs	Northeast	½
Veronica Medicinal Springs	Santa Barbara	Santa Barbara	West	4
Walters Mineral Springs	Napa	Pope Valley	Northeast	6

[a] Not a post office.

COLORADO.

There has been since 1911 a decrease each year in the quantity of mineral waters sold in Colorado. There was a decrease of 28 per cent in quantity in 1918, but an increase of 25 per cent in value, compared with decreases of 18 per cent in quantity and 46 per cent in value, in 1917. There was an increase of 10 cents in the average price received for the water, the price being 25 cents in 1918. The sales of medicinal waters increased from $25,679 in 1917 to $34,284 in 1918, and the sales of table waters from $39,490 in 1917 to $47,083 in 1918.

Reports were received from 11 active springs. Four bathing establishments were maintained—the same number as in 1917—and 3 resorts, accommodating about 1,700 guests. In the manufacture of soft drinks 176,831 gallons of water was used. Lithia Springs are now called Pueblo Mineral Springs.

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Mineral waters sold in Colorado, 1914–1918.

Year.	Commercial springs.	Quantity sold.	Value.	Average price per gallon.
		Gallons.		*Cents.*
1914	12	968,260	$113,413	12
1915	14	858,185	63,104	7
1916	12	542,185	120,509	22
1917	12	442,815	65,169	15
1918	10	319,542	81,367	25

Sources of mineral waters sold in Colorado in 1918.

Spring or well.	Location.			
	County.	Nearest post office.	Direction from post office.	Distance from post office.
				Miles.
Boulder Springs	Boulder	Crisman[a]	East	½
Canyon City Soda Springs	Fremont	Canyon City		
Clark Magnetic Mineral Well	Pueblo	Pueblo	South	1
Horn Mineral Springs	El Paso	Colorado Springs		
Lithia Spring	Pueblo	Pueblo		
Manitou, Navajo, Cheyenne, and Shoshone Springs.	El Paso	Manitou		
Pueblo Mineral Springs	Pueblo	Pueblo		
Ute Chief Manitou Spring	El Paso	Manitou		
Ute, Ouray, Little Chief, and Geyser Iron Springs.	do	do		
Waunita Hot Springs	Gunnison	Waunita Hot Springs		
Yampa Hot Springs	Garfield	Glenwood Springs	North	½

[a] Not a post office.

CONNECTICUT.

The output of mineral waters in Connecticut decreased 31 per cent in quantity and 30 per cent in value in 1918, the average price remaining the same, 5 cents. In 1917 a decrease in the sales of table waters and a 63 per cent increase in the sales of medicinal waters were reported. The returns for 1918 show a very decided increase in the value of medicinal waters—from $3,127 in 1917 to $12,073—and a decrease—from $100,851 in 1917 to $60,454 in 1918—in the value of table waters sold. The total value of sales in 1918 was $72,527.

Del-Vale Spring, situated near Canton, reported for the first time. Twenty-seven active springs reported, or four less than in 1917. No resorts or mineral-water baths were reported. About 278,663 gallons of mineral waters was used in the manufacture of soft drinks, a decrease of 31,197 gallons from the quantity used in 1917.

Mineral waters sold in Connecticut, 1914–1918.

Year.	Commercial springs.	Quantity sold.	Value.	Average price per gallon.
		Gallons.		*Cents.*
1914	42	2,341,083	$134,478	6
1915	38	1,774,213	101,970	6
1916	34	2,837,878	133,768	5
1917	31	1,964,096	103,978	5
1918	27	1,364,443	72,527	5

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Sources of mineral waters sold in Connecticut in 1918.

Spring or well.	Location.			
	County.	Nearest post office.	Direction from post office.	Distance from post office.
				Miles.
Althea Spring	New Haven	Waterbury	South	2
Bailey Natural Spring	Fairfield	Danbury	West	2
Barcla Spring	do	do		
Beaver Spring	New Haven	Ansonia	East	1
Camp Meeting Spring	do	Milford	Northwest	2½
Cherry Hill Spring	do	Highwood	North	2
Crystal Spring	Middlesex	Middletown	Northwest	2½
Do	New Haven	Derby	North	1½
Del-Vale Spring	Hartford	Canton	Northeast	1
Elco Springs	do	Bristol	West	1½
Ellis Mountain Spring	Fairfield	Danbury	do	3
Granite Rock Spring	Middlesex	Higganum	Southeast	1
Gra-Rock Spring	Hartford	Canton	Southwest	¼
Hermitage and Rockledge Springs.	New Haven	New Haven	Northeast	4
Highland Spring	Middlesex	Meriden	do	4
Hillside Spring	New Haven	do	West	1½
Hosmer Mountain Spring	Windham	Willimantic		
Indian Spring	Fairfield	Shelton	West	¾
Live Oak Spring	New Haven	Meriden	Southeast	¼
Mammanasco Spring	Spring	Fairfield	Northwest	4
Oak Spring	Middlesex	Middletown		
Pequabuck Mountain Spring	Hartford	Bristol	West	2
Pequot Spring	do	Glastonbury	Northeast	1
Richardson Spring	Litchfield	Torrington	Southwest	1½
Rock Spring	Fairfield	Bridgeport	Northwest	3½
Stafford Spring	Tolland	Stafford Springs		
Varuna Spring	Fairfield	Stamford	North	6
Venture Rock Spring	New London	Stonington	Southeast	4

DELAWARE.

Reports have been received from only one spring in Delaware during the last eight years, the water being used chiefly on the table by residents of Wilmington. The spring is called Kiamensi Springs, near Wilmington, Newcastle County.

DISTRICT OF COLUMBIA.

One spring in the District of Columbia reported sales during 1918, namely, Red Oak Spring, near Langdon.

FLORIDA.

Returns from Florida showed an increase of 16 per cent in quantity and 31 per cent in value of mineral waters sold in 1918, as compared with 1917. Five springs were active in 1918. One spring idle in 1917 produced in 1918 and two springs active in 1917 reported no sales for 1918. Another spring from which no report was received was considered idle.

The total output was 164,630 gallons, valued at $12,883. The average price per gallon decreased from 7 cents to 6 cents.

Two bathing establishments and two resorts, accommodating 300 persons, were maintained.

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Sources of mineral waters sold in Florida in 1918.

Spring or well.	Location.			
	County.	Nearest post office.	Direction from post office.	Distance from post office
				Miles.
Espritu Santo Springs	Pinellas	Safety Harbor		
Good Hope Mineral Wells	Duval	Jacksonville	Northwest	6
Hampton Springs	Taylor	Hampton Springs		
Purity Springs	Hillsborough	Tampa	North	6
Stomawa Well	do	do	North	7

GEORGIA.

The sales of mineral waters in Georgia decreased 24 per cent in quantity and 26 per cent in value in 1918, and the price per gallon remained about the same, 9 cents. The sales were 314,388 gallons, valued at $27,810. One bathing establishment and two resorts, accommodating 550 guests, were maintained at springs. Two springs active in 1917 were idle in 1918; one spring from which no report was received has been considered idle; and one spring from which no report was received in 1917 was active in 1918. Crystal Mineral Spring reported sales for the first time.

Sources of mineral waters sold in Georgia in 1918.

Spring or well.	Location.			
	County.	Nearest post office.	Direction from post office.	Distance from post office.
				Miles.
Benscot Mineral Springs	Cobb	Austell	Northwest	¼
Catoosa Springs	Catoosa	Tunnel Hill	North	3
Crystal Mineral Springs	Chatham	Savannah		6
High Point Mineral Wells	Bibb	Macon		
High Rock Spring	Fulton	Atlanta	East	3
Jay Bird Spring	Dodge	Helena	North	7
Millers Mineral Spring	Baldwin	Milledgeville	North	½
Pine Mountain Spring	Harris	West Point	Southeast	3
White Oak Mineral Well	Bibb	Macon	West	4
Windsor Spring	Richmond	Gracewood	West	3

ILLINOIS.

The sales of mineral waters in Illinois decreased 33 per cent in quantity and 34 per cent in value in 1918. The total sales were 921,953 gallons, valued at $43,448, of which $1,337 was received for medicinal waters and $42,111 for table waters. Three springs active in 1917 reported no sales for 1918, and one from which no report was received was estimated.

The quantity of mineral waters used in the manufacture of soft drinks decreased from 44,043 to 32,668 gallons. Resorts for about 400 guests were maintained at 4 springs, and mineral-water bathing establishments were maintained at 6 springs.

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Mineral waters sold in Illinois, 1914–1918.

Year.	Commercial springs.	Quantity sold.	Value.	Average price per gallon.
		Gallons.		*Cents.*
1914	21	1,760,030	$81,307	5
1915	23	1,559,489	75,290	5
1916	21	1,777,741	94,056	5
1917	16	1,370,461	66,042	5
1918	13	921,953	43,448	5

Sources of mineral waters sold in Illinois in 1918.

Spring or well.	Location.			
	County.	Nearest post office.	Direction from post office.	Distance from post office.
				Miles.
Abana Mineral Springs	Lake	Libertyville		
Central Park Sulphur Well	Peoria	Peoria	Northwest	1
Diamond Mineral Spring	Madison	Highland	North	6
Glen Flora Mineral Springs	Lake	Waukegan		
Gravel Springs	Morgan	Jacksonville	Northwest	5
Minerva Mineral Spring	McHenry	Cary Station		
Montgomery Magnesia Spring	Kane	Montgomery		
Na-ma-no-ma; Old Ironsides; Springs	Pope	Dixon Springs	Northwest	
Ripley Mineral Spring	Brown	Ripley	....do	2
Sanicula Mineral Spring	La Salle	Ottawa		
Sulphur Lick Spring	....do	Wedron	South	1
Woodmen Artesian Well	Rock Island	Rock Island	Southwest	

INDIANA.

Indiana sold 555,076 gallons of mineral waters in 1918—6 per cent more than in 1917—valued at $179,431. The average price per gallon increased from 29 to 32 cents. There was an increase in the sales of both medicinal and table waters. Five springs active in 1917 reported no sales in 1918. Five bathing establishments and four resorts, accommodating 900 guests, were maintained.

Sources of mineral waters sold in Indiana in 1918.

Spring or well.	Location.			
	County.	Nearest post office.	Direction from post office.	Distance from post office.
				Miles.
Blue Cast Well	Allen	Woodburn		
Bronson Well	Vigo	Terre Haute	East	
Carlson's Mineral Springs	La Porte	La Porte	North	8
Cartersburg Spring	Hendricks	Cartersburg		
Greenwood Spring	Allen	Fort Wayne		
Holman Mineral Well	Montgomery	Crawfordsville	Southwest	1½
McCullough Springs	Gibson	Oakland City	South	1½
Mount Jackson Mineral Well	Marion	Indianapolis	West	4
Pluto, Proserpine, and Bowles Springs	Orange	French Lick	North	
White Crane Well	Dearborn	Dillsboro	West	1

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IOWA.

The reported output of mineral waters in Iowa during 1918 was 87,703 gallons, sold for $3,937, as compared with 99,103 gallons, sold for $12,125, in 1917. These figures correspond to a decrease in quantity and value, respectively, of 12 per cent and 68 per cent. The average price per gallon decreased from 12 to 4 cents. One spring which was active in 1917 was not heard from in 1918 and has been considered idle. Lime Rock Spring is added to the list for the first time. More than 200,000 gallons of mineral waters was used in the manufacture of soft drinks. No mineral-water bathing establishments nor resorts were maintained.

Sources of mineral waters sold in Iowa in 1918.

Spring or well.	Location.			
	County.	Nearest post office.	Direction from post office.	Distance from post office.
				Miles.
Fry's Well	Jasper	Colfax	Northeast	
Grand Hotel Mineral Spring	do	do		
Hawkeye Hygeia Well	Woodbury	Sioux City	West	
Lime Rock Spring	Dubuque	Dubuque	North	3

KANSAS.

The mineral-water business in Kansas showed an increase in 1918 in both quantity and value. The total sales amounted to 403,862 gallons, or 40 per cent more than in 1917, valued at $75,359, or 11 per cent more than in 1917. The average price per gallon dropped from 23 to 19 cents. One spring active in 1917 reported no sales in 1918. Two mineral-water bathing establishments accommodated 70 guests at two resorts. Fifteen thousand gallons of mineral waters was used in the manufacture of soft drinks.

Sources of mineral waters sold in Kansas in 1918.

Spring or well.	Location.			
	County.	Nearest post office.	Direction from post office.	Distance from post office.
				Miles.
Abilena Wells	Dickson	Abilene		
Aganippe Spring	Montgomery	Independence	Southeast	4½
Blasing's Springs	Riley	Manhattan	do	12
California Spring	Franklin	Ottawa	Northwest	5
Crystal Springs	Montgomery	Coffeyville	Northeast	1½
Nature's Best Wells	Summer	Conway Springs	Southwest	½
Riverview Mineral Springs	Cowley	Winfield	West	1
Sycamore Mineral Springs	Brown	Morrill	Northwest	4½
Viola Springs	Sedgewick	Viola	North	5
Waconda Springs	Mitchell	Waconda Springs	South	

KENTUCKY.

The reports for 1918 show a decline in the quantity of mineral water sold in Kentucky. There was a decrease of 15 per cent in quantity but an increase of 4 per cent in value. The sales reported in

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1918 amounted to 255,852 gallons, as compared with 301,748 gallons in 1917, and the value of the output was $41,997, as compared with $40,189 in 1917. The average price increased from 13 to 16 cents. Two springs which marketed water in 1917 reported no sales in 1918; two springs which were active in 1917 were not heard from in 1918; one spring idle in 1917 reported sales in 1918; and one new spring was added to the list; thus the total number of active springs was 11. Renfo Mineral Springs was added to the list for the first time.

Three resorts, accommodating 115 guests, exclusive of the capacity of Dawson Springs, and two mineral-water bathing establishments were maintained. In addition to this 65,520 gallons of mineral water was used in making soft drinks.

Sources of mineral waters sold in Kentucky in 1918.

Spring or well.	Location.			
	County.	Nearest post office.	Direction from post office.	Distance from post office.
				Miles.
Anita Springs	Oldham	La Grange	Southwest	1
Cole's Lexington Lithia Springs	Fayette	Lexington	North	2
Doom's Wells	Hopkins	Dawsonsprings		
Hamby's Well	do	do	South	
H. and H. Well	do	do		
Kentucky Mineral Well	Taylor	Campbellsville	South	5
Renfo Mineral Springs	Fayette	Lexington		
Robson Spring	Campbell	Fort Thomas		
Royal Magnesian Spring	Oldham	La Grange	West	1
St. Patricks Well	Jefferson	Louisville		
Kentucky Carlsbad Spring	Grant	Dry Ridge		

LOUISIANA.

Only one spring in Louisiana reported in 1918. The water was sold for medicinal purposes.

The spring is named Krotz Springs, Krotz Springs, St. Landry Parish.

MAINE.

The output of mineral water in Maine was 829,338 gallons, valued at $266,168; the number of active springs decreased from 24 to 21. The average price per gallon was 32 cents. One spring active in 1917 reported no sales in 1918; two springs from which no reports were received were omitted; and one spring from which no report was received was estimated.

The mineral water used in the manufacture of soft drinks was 70,196 gallons, a decrease of 16,307 gallons from the quantity used in 1917. One resort for guests was maintained, but no bathing establishments using mineral water were reported.

Mineral waters sold in Maine, 1914–1918.

Year.	Commercial springs.	Quantity sold.	Value.	Average price per gallon.
		Gallons.		*Cents.*
1914	29	1,082,631	$333,234	31
1915	24	1,115,648	338,003	30
1916	24	1,038,861	353,792	34
1917	24	1,014,064	343,587	34
1918	21	829,338	266,168	32

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Sources of mineral waters sold in Maine in 1918.

Spring or well.	Location.			
	County.	Nearest post office.	Direction from post office.	Distance from post office.
				Miles.
Baker Puritan Spring	York	Old Orchard	Northwest	1½
Boothbay Mineral Spring	Lincoln	East Boothbay		
Forest Springs	Kennebec	Gardiner	Southwest	6
Glenrock Cold Spring	Androscoggin	Greene	South	2
Glenwood Spring	Kenrebec	Augusta	do	¾
Hanover Spring	Oxford	Hanover	Northwest	¾
Highland Spring	Androscoggin	Lewiston	East	2
Keystone Mineral Spring	do	Poland		
Mount Desert Spring	Hancock	Northeast Harbor	North	1
Mount Zircon Spring	Oxford	Rumford Falls		
Mystic Spring	York	Saco		
Oak Grove Spring	Penobscot	Brewer	Northeast	1
Pine Spring	Sagadahoo	Topsham	do	2½
Poland Mineral Spring	Androscoggin	Poland	do	¾
Purity Spring	Cumberland	West Scarboro	Southwest	1½
Redman Farm Spring	Waldo	Belfast	South	4
Rocky Hill Spring	Somerset	Fairfield	North	2
Skowhegan Crystal Spring	do	Skowhegan		1
Thorndike Mineral Spring	Waldo	Thorndike	East	4
Underwood Spring	Cumberland	Portland	Northeast	7
Wawa Lithia Spring	York	Moody	South	½

MARYLAND.

Reports for 1918 show an increase, as compared with 1917, of 5 per cent in quantity and 16 per cent in value of mineral water sold in Maryland. There had been a decline in 1917 of 21 per cent in quantity and 12 per cent in value. The total sales in 1918 amounted to 1,089,966 gallons, valued at $100,575. The output was almost entirely table water. Green Spring reported sales for the first time. In addition to the quantity reported sold, 119,642 gallons was used in the manufacture of soft drinks, as compared with 175,426 gallons in 1917. One resort for guests was maintained, but no bathing establishments using mineral water.

Mineral waters sold in Maryland, 1914–1918.

Year.	Commercial springs.	Quantity sold.	Value.	Average price per gallon.
		Gallons.		*Cents.*
1914	10	1,691,776	$124,403	7
1915	10	1,433,406	105,581	7
1916	9	1,312,788	99,020	8
1917	7	1,036,045	86,938	8
1918	8	1,089,966	100,575	9

Sources of mineral waters sold in Maryland in 1918.

Spring or well.	Location.			
	County.	Nearest post office.	Direction from post office.	Distance from post office.
				Miles.
Big Rock Spring	Frederick	Thurmont	West	1
Brooklandwood Spring	Baltimore	Lutherville	do	2½
Buena Vista Spring	Washington	Edgemont		
Caton Spring	Baltimore	Catonsville	East	1
Chattolanee Springs	do	Garrison	Southeast	1
Green Spring	Washington	Big Spring	Southwest	2
Mardela Mineral Spring	Wicomico	Mardela Springs		
Rock Crystal Spring	Baltimore	Baltimore	West	4

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MASSACHUSETTS.

Returns from Massachusetts for 1918 indicate a decrease of 31 per cent in quantity and 10 per cent in value of mineral waters sold. The average price per gallon increased from 5 to 6 cents. The sales amounted to 1,999,592 gallons, valued at $125,208. In addition to the quantity reported as sold, 1,819,246 gallons was used in the manufacture of soft drinks, as compared with 893,926 gallons in 1917—an increase of 104 per cent. One spring active in 1917 reported no sales in 1918, and 3 springs active in 1917 were not heard from in 1918. Mount Vernon Spring is now called Cline Spring.

One small resort was maintained, and one mineral-water bathing establishment was reported.

Mineral waters sold in Massachusetts, 1914–1918.

Year.	Commercial springs.	Quantity sold.	Value.	Average price per gallon.
		Gallons.		*Cents.*
1914	52	3,084,385	$174,324	6
1915	48	3,872,192	184,133	5
1916	51	3,124,096	128,478	4
1917	48	2,908,638	139,075	5
1918	43	1,999,592	125,208	6

Sources of mineral waters sold in Massachusetts in 1918.

Spring or well.	Location.			
	County.	Nearest post office.	Direction from post office.	Distance from post office
				Miles.
Abbotts Spring	Essex	Methuen	East	2½
Ballardvale Springs	do	North Wilmington	Northeast	2
Belmont Crystal Spring	Middlesex	Belmont	do	1½
Burnham Spring	Essex	Methuen		
Cadwells Crystal Spring	Middlesex	Woburn	Southeast	1½
Cascella Springs	Hampden	Palmer		
Chelmsford Spring	do	Chelmsford	Southwest	1
Chickatawbut Spring	Norfolk	South Braintree	East	7
Cline Spring	Essex	Lawrence	Southwest	2
Cochato Spring	Norfolk	South Braintree	East	3
Crystal Spring	Essex	West Peabody	Northwest	½
Deep Glen Spring	do	West Lynn	North	1½
El-Azhar Spring	Middlesex	Tyngsboro	East	3
Goulding Spring	Plymouth	Whitman	West	1
Great Radium Springs	Berkshire	Pittsfield	Northwest	2½
Holyoke Spring	Essex	West Lynn		
King Philip Spring	Plymouth	Mattapoisett	North	2
Klines Spring	Essex	Lawrence		
Milton Spring	Norfolk	Milton		
Monatiquot	do	South Braintree	East	1
Mount Blue Mineral Spring	Plymouth	North Scituate	West	5
Mount Holyoke Spring	Hampshire	South Hadley		
Mount Pleasant Spring	Middlesex	Lowell	Southwest	2½
New Abbott Spring	Essex	Methuen	West	2½
Nobscot Mountain Spring	Middlesex	Framingham		
October Spring	Berkshire	Lenox	Southeast	3
Pearl Hill Spring	Worcester	Fitchburg	East	1½
Pepperell Spring	Middlesex	Pepperell	North	2
Pequot Mineral Spring	do	Cochituate	Southeast	¼
Pocahontas Spring	Essex	Lynnfield Center	North	1
Polar Spring	Worcester	Spencer	Northeast	2
Puritan Spring	Essex	Andover	South	1½
Purity Spring	do	Danvers	Southeast	2
Do	Middlesex	Chelmsford	North	2½
Robbins Spring	do	Arlington Heights	Southwest	1½
Sand Spring	Berkshire	Williamstown		
Shawmut Spring	Norfolk	East Milton	Southwest	1½
Simpson Spring	Bristol	South Easton	South	¾
Sterling Spring	Essex	West Lynn	West	3
Stevens Spring	do	Lawrence		
Valpey Spring	do	do		
Whitman Spring	Plymouth	Whitman	North	1
Wilbraham Spring	Hampden	Wilbraham	West	½

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MICHIGAN.

The total sales of mineral waters in Michigan in 1918 was 1,216,882 gallons, as compared with 1,069,164 gallons in 1917, an increase of 14 per cent; and the total value was $129,592, as compared with $105,641 for 1917. The sales of table waters amounted to $128,809, and medicinal waters netted only $783. Two springs active in 1917 were not heard from in 1918 and have been considered idle, and one spring active in 1917 reported no sales in 1918; thus the number of active springs decreased from 12 to 9. Two resorts accommodating 1,000 guests were maintained, but no bathing establishments were operated.

In addition to the mineral water sold about 31,200 gallons, as compared with 43,700 gallons in 1917, was used in the manufacture of soft drinks.

Mineral waters sold in Michigan, 1914–1918.

Year.	Commercial springs.	Quantity sold.	Value.	Average price per gallon.
		Gallons.		*Cents.*
1914	22	931,343	$70,310	8
1915	19	913,765	72,711	8
1916	18	996,875	108,867	11
1917	12	1,069,164	105,641	10
1918	9	1,216,882	129,592	11

Sources of mineral waters sold in Michigan in 1918.

Spring or well.	Location.			
	County.	Nearest post office.	Direction from post office.	Distance from post office.
				Miles.
Andrew Magnetic Mineral Spring	Gratiot	Saginaw West Side		
Artic Spring	Kent	Grand Rapids	Northwest	½
Maple Leaf Springs	Macomb	Mount Clemens		
Mount Clemens Well	do	do		
Ogemaw Spring	Ogemaw	Maltby	South	½
Panacea Spring	Macomb	Mount Clemens		
Ponce de Leon Spring	Kent	Grand Rapids	South	6
Silver Springs	Wayne	Northville		
Victory Spring	Macomb	Mount Clemens		

MINNESOTA.

According to reports received from 16 active springs in Minnesota, the sales of mineral waters in that State decreased 25 per cent in quantity and 10 per cent in value in 1918. The total output was 2,248,731 gallons, valued at $99,159. The sales of table water increased from $77,436 in 1917 to $98,976 in 1918, but the sales of medicinal waters decreased from $32,528 in 1917 to only $183 in 1918. The average price per gallon remained the same, 4 cents. All the springs that were active in 1917 reported sales in 1918 except one. One resort for guests and one mineral-water bathing establishment were operated at springs. In addition to the sales reported 278,651 gallons were used in the manufacture of soft drinks.

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Mineral waters sold in Minnesota, 1914–1918.

Year.	Commercial springs.	Quantity sold.	Value.	Average price per gallon.
		Gallons.		*Cents.*
1914	15	5,639,232	$194,041	3
1915	17	3,493,887	136,259	4
1916	18	4,188,434	145,582	3
1917	17	3,004,546	109,964	4
1918	16	2,248,731	99,159	4

Sources of mineral waters sold in Minnesota in 1918.

Spring or well.	Location.			
	County.	Nearest post office.	Direction from post office.	Distance from post office.
				Miles.
Campbells Spring	Ottertail	Fergus Falls		
Clear Spring	Hennepin	Hopkins	West	5
Deep Spring	Polk	Crookston		
Glenwood-Inglewood Spring	Hennepin	Minneapolis	West	2½
Indian Medical Spring	Sherburne	Elk River		
Highland Spring	Ramsey	St. Paul	Southeast	3
Mankato Mineral Spring	Blue Earth	Mankato		
Ogahmah Spring	Pennington	Thief River Falls		
Owens Spring	Pope	Glenwood	North	1
Pokegama Spring	Becker	Detroit	East	2
Red Star Springs	Stearns	Cold Spring	Northeast	¼
Rock Spring	Scott	Shakopee		
Rosendale Spring	Watonwan	St. James		
Silver Spring	Lyon	Marshall		
Do	Bigstone	Ortonville	North	
Ward Springs	Todd	Ward Springs	South	1

MISSISSIPPI.

The mineral-water business in Mississippi, which decreased notably in 1917, underwent a further decrease of 11 per cent in quantity and 5 per cent in value in 1918, the sales reported being 175,533 gallons, all classed as medicinal water, valued at $47,539, as compared with 197,555 gallons, valued at $49,786 in 1917. The price per gallon increased from 25 to 27 cents. Two springs active in 1917 reported no sales in 1918, and 3 springs which reported sales in 1917 and were not heard from in 1918 were considered idle. The report of one spring was estimated. One mineral-water bathing establishment and four resorts, accommodating about 1,000 guests, were maintained at springs.

Sources of mineral waters sold in Mississippi in 1918.

Spring or well.	Location.			
	County.	Nearest post office.	Direction from post office.	Distance from post office.
				Miles.
A[illegible] Wells	Madison	Way	East	1
B[illegible] Wells	Copiah	Hazlehurst	West	10
Do[illegible] Mineral Spring	Jasper	Vosburg	South	1
Mor[illegible] neral Spring	do	do	North	¼
Red S[illegible]g	Montgomery	Stewart	Southwest	3
Robin[illegible] Spring	Madison	Pocahontas		Near.
Staffor[illegible] ring	Jasper	Vosburg	East	2

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MISSOURI.

The decrease in the sales of mineral waters in 1917 in Missouri was marked by a further decline in the output in 1918 of 24 per cent in quantity and 33 per cent in value. The total output for 1918 was 306,299 gallons, valued at $38,478. The average price per gallon decreased from 14 to 13 cents. In addition to the quantity reported as sold, 13,787 gallons was used in the manufacture of soft drinks, a decrease from the quantity reported for 1917 of 21,436 gallons, or 61 per cent. Reports for 1918 were received from 26 active springs, as compared with 33 in 1917. Three springs active in 1917 reported no sales in 1918, and four springs active in 1917 were not heard from in 1918 and were considered idle. Two resorts, exclusive of those at Excelsior Springs, and three mineral-water bathing establishments were operated.

Sources of mineral waters sold in Missouri in 1918.

Spring or well.	Location.			
	County.	Nearest post office.	Direction from post office.	Distance from post office
				Miles.
B. B. Spring	Pike	Bowling Green		
Fonzo Spring	do	do		
Belcher Artesian Well	St. Louis	St. Louis		
Bokert Springs	Jefferson	De Soto	West	4
Bowling Green Lithia Water Spring.	Pike	Bowling Green		
Chalybeate Spring	Lawrence	Paris Springs		
Chouteau Springs	Cooper	Boonville	Southwest	10
Crystal Mineral and Saline Soda Wells.	Clay	Excelsior Springs		
Eldorado Aperient Water Well	Cedar	Eldorado Springs		
Excelsior Saline Well	Clay	Excelsior Springs		
Grand River Mineral Spring	Mercer	Mercer	Northwest	5½
Haymaker Well	do	Lineville, Iowa	Southwest	3½
Hornet Spring	Pike	Bowling Green		
Jackson Spring	Jackson	Mount Washington	North	¼
Laxative Mineral Well	Cedar	Eldorado Springs		
Lithia No. 1 Well	Clay	Excelsior Springs	Northeast	¼
McAllister Springs	Saline	Houstonia	North	3½
Natrona Wells	Clay	Excelsior Springs	Northeast	¼
Park Spring	Cedar	Eldorado Springs		
Regent, Siloam, Soterian, Sulpho-Saline Springs.	Clay	Excelsior Springs		
Salax Well	do	do		
Sweet Spring	Saline	Sweet Springs	South	1
White Spring	Jackson	Independence		

MONTANA.

The sales from three springs reporting from Montana in 1918 were 193,557 gallons, valued at $8,912. This represents a loss in quantity in 1918 of 8 per cent and in value of 7 per cent. The same springs active in 1917 reported for 1918, with one exception.

Mineral-water bathing establishments were maintained at two of these springs, and one resort accommodating 100 guests was reported. Practically all the water was sold for table use.

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Sources of mineral waters sold in Montana in 1918.

Spring or well.	Location.			
	County.	Nearest post office.	Direction from post office.	Distance from post office.
				Miles.
Alhambra Hot Springs	Jefferson	Alhambra		
Lissner Mineral Spring	Lewis and Clark	Helena	Southeast	4
Rock Creek	Carbon	Red Lodge		

NEBRASKA.

Reports were received from three springs in Nebraska in 1918, from one of which the water was sold entirely for medicinal purposes. The sales amounted to 1,080 gallons, valued at $155, the average price being 14 cents. In addition, 100,000 gallons was used in the manufacture of soft drinks. One bathing establishment was maintained at one of the springs.

Sources of mineral waters sold in Nebraska in 1918.

Spring or well.	Location.	
	County.	Nearest post office.
Brown Park Mineral Springs	Douglas	Omaha.
Curo Mineral Spring	do	Do.
Shogo Lithia Spring	Seward	Milford.

NEVADA.

One spring reported sales of mineral waters in 1918 in Nevada, the entire output being sold for table use.

The spring is called the Diamond Spring, Reno, Washoe County.

NEW HAMPSHIRE.

Returns from New Hampshire indicate a substantial increase in both quantity and value of mineral water marketed in 1918. The total sales in 1918 were 182,326 gallons, as compared with 105,181 gallons in 1917, and the total value of the output was $8,256, as compared with $6,975 in 1917. All of the output was classified as table water. The average price per gallon decreased from 7 to 5 cents. Three springs that were active in 1917 reported no sales in 1918, and one spring which was not heard from was omitted. No new springs were reported. In addition to the mineral water sold, 377,403 gallons was used in the manufacture of soft drinks, as compared with 477,937 gallons in 1917.

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Sources of mineral waters sold in New Hampshire in 1918.

Spring or well.	Location.			
	County.	Nearest post office.	Direction from post office.	Distance from post office.
				Miles.
Granite State Springs	Rockingham	Atkinson Depot	Northeast	½
Laconia Spring	Belknap	The Weirs		
White Mountain Mineral Springs.	Carroll	Redstone	South	1

NEW JERSEY.

The sale of mineral waters in New Jersey decreased from 1,283,157 gallons in 1917 to 1,134,848 gallons in 1918, a loss in quantity of nearly 12 per cent and in value from $115,188 to $110,150, or about 4 per cent. The average price per gallon was 10 cents. Most of the output was classified as table water. In addition to the water reported as sold, 47,264 gallons was used in the manufacture of soft drinks, as compared with 73,605 gallons used in that business in 1917 No new springs were reported; one spring which reported sales in 1917 failed to report for 1918; thus the number of active springs decreased from 14 to 13. One mineral-water bath was reported to have been maintained.

Mineral waters sold in New Jersey, 1914–1918.

Year.	Commercial springs.	Quantity sold.	Value.	Average price per gallon.
		Gallons.		*Cents.*
1914	17	1,710,030	$155,649	9
1915	13	1,479,479	116,226	8
1916	15	1,580,028	130,993	8
1917	14	1,283,157	115,188	9
1918	13	1,134,848	110,150	10

Sources of mineral waters sold in New Jersey in 1918.

Spring or well.	Location.			
	County.	Nearest post office.	Direction from post office.	Distance from post office.
				Miles.
Alpha Spring	Union	Springfield	Southwest	3½
Belmar Spring	Bergen	Ridgewood	South	1
Cold Indian Spring	Monmouth	Asbury Park	West	3½
Culm Rock Spring	Somerset	Pluckemin		
Echo Spring	Mercer	Trenton	North	5
Grey Rock Artesian Well	do	do		
Indian Spring	Morris	Rockaway		
Kalium Spring	Camden	Collingswood	Southeast	½
Kanouse-Oakland Spring	Bergen	Oakland	West	1
Pilgrim Spring	do	Ridgefield Park		
Rock Spring	Essex	West Orange		
Washington Rock Spring	Somerset	Plainfield		
Watchung Spring	do	do	North	2½

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NEW MEXICO.

Reports of sales of mineral waters in New Mexico in 1918 were received from one well only, which is called Perry Well and is 15 miles southeast of Albuquerque.

NEW YORK.

The State of New York in 1918 ranked first in number of active mineral springs, second in total quantity of mineral waters sold, second in total value of sales and in value of table waters, third in value of medicinal waters, and ninth in consumption of mineral waters for the manufacture of soft drinks. Comparison of figures for 1918 with those of 1917 shows a decrease of 25 per cent in quantity and an increase of less than 1 per cent in value in 1918. Most of the water was sold for table use. In 1918 there were 50 active springs, as against 65 in 1917. An additional quantity of 250,478 gallons was used in the manufacture of soft drinks in 1918. Two resorts, besides those at Saratoga Springs, and three mineral-water bathing establishments were operated in 1918. Sun Ray Spring is now called Clysmic Spring, and the name of Monarch Spring has been changed to Taconic Spring.

Mineral waters sold in New York, 1914–1918.

Year.	Commercial springs.	Quantity sold.	Value.	Average price per gallon.
		Gallons.		*Cents.*
1914	69	8,201,202	$672,913	8
1915	75	8,411,616	711,697	8
1916	68	7,746,490	697,650	9
1917	65	7,819,314	562,874	7
1918	50	5,887,746	566,910	10

Sources of mineral waters sold in New York in 1918.

Spring or well.	Location.			
	County.	Nearest post office.	Direction from post office.	Distance from post office.
				Miles.
Aldena Park Spring	Erie	Alden		
Arlington Spring	Dutchess	Arlington	North	3
Baldwin Mineral Spring	Cayuga	Cayuga	Northeast	2
Breesport Oxygenated Mineral Spring	Chemung	Breesport		
Briarcliff Spring	Westchester	Briarcliff Manor	North	1
Carrier Spring	St. Lawrence	Potsdam		
Chester Crest Spring	Westchester	Mount Vernon	North	1
Clinton Mineral Spring	Oneida	Franklin Springs	South	½
Clysmic Spring	Ulster	Ellenville		½
Coesa Spring	Saratoga	Saratoga Springs	Southwest	2½
Cold Spring	St. Lawrence	Starlake	South	½
Comstock Well	Saratoga	Ballston Spa	Northeast	½
Crystal Springs	Oneida	Whitesboro	Southwest	½
Deer Run Springs	Chautauqua	Dunkirk	South	2
Eagle Spring	Greene	Lanesville	Northeast	3
Elixir Spring	Ulster	Clintondale		
Elk Spring	Erie	Lancaster	East	2
Ferndell Spring	Saratoga	Saratoga Springs	Southwest	2
Flint Spring	Rensselaer	West Sand Lake		
Franklin Lithia Spring	Oneida	Franklin Springs	South	½
Gardner White Sulphur Springs	Schoharie	Sharon Springs	North	½

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Sources of mineral waters sold in New York in 1918—Continued.

Spring or well.	Location.			
	County.	Nearest post office.	Direction from post office.	Distance from post office.
				Miles.
Geneva Mineral Spring	Ontario	Geneva		
Geyser Spring	Saratoga	Saratoga Springs	Southwest	2
Glen Alex Spring	Oneida	Washington Mills	East	1/16
Gramatan Spring	Westchester	Bronxville	East	½
Granite Spring	....do	Granite Springs		
Great Bear Springs	Oswego	Fulton	South	5
Greendale Crystal Springs	Columbia	Greendale	East	3
Hathorn No. 2	Saratoga	Saratoga Springs	Southwest	4¼
Ideal Spring	Rensselaer	Troy		
Kirkland Spring	Oneida	Franklin Springs	South	½
Lithia Polaris and Adirondack Springs.	....do	Boonville	South	2
Mammoth Spring	Rensselaer	West Sand Lake	West	2
Mohawk Spring	Montgomery	Amsterdam		
Mohican Spring	Saratoga	Ballston Spa	North	½
Plymouth Spring	Rensselaer	Troy	South	3
Risley Cold Springs	Oneida	New York Mills		
Saratoga Vichy Spring	Saratoga	Saratoga Springs		
Setauket Spring	Suffolk	Setauket	Northeast	1
Shell Rock Spring	....do	Rensselaer	South	4
Sparkling Spring	Erie	Buffalo		
Split Rock Lithia Spring	Oneida	Franklin Springs	South	½
Standard Spring	Rensselaer	Troy		
Table Rock Mineral Spring	Monroe	Honeoye Falls	Northwest	1½
Taconic Spring	Dutchess	Beacon	Southeast	2½
Tréspur Artesian Well	Cortland	McGraw	Southwest	½
Victoria No. 2 Spring	Saratoga	Saratoga Springs		
Vita Spring	Washington	Fort Edward	Southeast	1½
Westmoreland Mineral Spring	Oneida	Westmoreland	Northeast	½
White Bear Spring	Genesee	Batavia	East	3

NORTH CAROLINA.

The sales of mineral waters in North Carolina showed a decrease in 1918 of 37 per cent in quantity and 48 per cent in value. The average price per gallon decreased from 15 to 12 cents. The sales amounted to 65,422 gallons, valued at $8,174, as compared with 103,659 gallons, valued at $15,664, in 1917. Six springs active in 1917 reported no sales in 1918; three springs were not heard from; Rock Hill Spring reported for the first time; thus the number of active springs in 1918 decreased from 18 to 10. Four resorts, accommodating about 500 guests, and one establishment for bathing in mineral water were maintained at springs.

Sources of mineral waters sold in North Carolina in 1918.

Spring or well.	Location.			
	County.	Nearest post office.	Direction from post office.	Distance from post office.
				Miles.
All Healing Spring	Alexander	Taylorsville	West	6
Derita Calcic Spring	Mecklenburg	Derita	East	1
Huckleberry Springs	Durham	West Durham	Southwest	2
Moores Springs	Stokes	Moores Springs		
Mount Vernon Springs	Chatham	Mount Vernon Springs		
Rivermont Carbonated Spring	Durham	West Durham	Southwest	3½
Rock Hill Spring	....do	Durham	West	4
Seven Springs	Wayne	Sevensprings	West	½
Shelby Lithia Springs	Cleveland	Shelby	North	3
Vade Mecum Spring	Stokes	Vade Mecum		

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NORTH DAKOTA.

Reports of sales were received from three active springs in North Dakota—the same number as in 1917—which showed a decrease in sales of 5 per cent in quantity but an increase of 7 per cent in value. The total output was 530,000 gallons, valued at $13,700, as compared with 556,000 gallons, valued at $12,837, in 1917. In addition to the quantity reported as sold, 30,000 gallons was used in the manufacture of soft drinks, a very considerable decrease from 120,000 gallons, the quantity used in 1917.

Sources of mineral waters sold in North Dakota in 1918.

Spring or well.	Location.			
	County.	Nearest post office.	Direction from post office.	Distance from post office.
				Miles.
Granite Spring	Ward	Minot		
Kenmare Spring	do	Kenmare		
Stony Creek Well	Burke	Bowbells	East	1½

OHIO.

Returns from Ohio in 1918 showed a decrease in the sales of mineral waters of 11 per cent in quantity but an increase of 10 per cent in value. The total output was 2,771,485 gallons, valued at $150,711, as compared with 3,113,093 gallons, valued at $136,710 in 1917. The average price per gallon, which has been 4 cents for the last eight years, rose to 5 cents. The mineral water used in the manufacture of soft drinks decreased from 248,000 gallons to 145,000 gallons. Seven springs active in 1917 reported no sales in 1918; thus the number of active springs in 1918 was reduced to 24. Three resorts, accommodating about 300 guests, and one mineral-water bathing establishment were maintained.

Mineral waters sold in Ohio, 1914–1918.

Year.	Commercial springs.	Quantity sold.	Value.	Average price per gallon.
		Gallons.		*Cents.*
1914	35	3,558,413	$145,586	4
1915	36	3,501,343	133,416	4
1916	37	4,102,922	161,160	4
1917	31	3,113,093	136,710	4
1918	24	2,771,485	150,711	5

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Sources of mineral waters sold in Ohio in 1918.

Spring or well.	Location.			
	County.	Nearest post office.	Direction from post office.	Distance from post office.
				Miles.
Alba Springs	Cuyahoga	West Park		
Beech Rock Spring	Muskingum	Zanesville		
Bellmore Spring	Columbiana	Signal		
Collingwood Well	Lucas	Toledo		
Crystal Springs	Licking	Newark	North	2
Devonian Mineral Spring	Lorain	Lorain		
Elm Meade Spring	Trumbull	Youngstown	Northwest	4
Fargo Mineral Springs	Ashtabula	Ashtabula	Southeast	½
Fisher's Magnesia Mineral Spring.	Franklin	Columbus		
Gibson Spring	Mahoning	Youngstown	South	1
LaFrance Spring	Lucas	Toledo	West	4½
Maple Grove Mineral Spring	Ross	Chillicothe	Northwest	7
Minnehaha Spring	Cuyahoga	West Park		
Oak Place Spring	Summit	Akron		
Oak Ridge Mineral Springs	Sandusky	Greenspring		
Peerless and Puritas Springs	Cuyahoga	West Park		
Pine Tree Spring	Lake	Willoughby	Southeast	2
Puritas Spring	Cuyahoga	Berea		
Purity Spring	do	South Euclid		
Riblet Health Spring	Mahoning	Youngstown		
Sand Rock Mineral Well	Stark	Canton	Southeast	2
Sulphur Lick Springs	Ross	Chillicothe		
Tallewanda Mineral Springs	Preble	College Corner	Northwest	1
Wheeler Mineral Springs	Mahoning	Youngstown	East	

OKLAHOMA.

The output of mineral water in Oklahoma in 1918 was 1,166,485 gallons, valued at $20,249, as compared with 852,381 gallons, valued at $26,997 in 1917. These figures indicate an increase of 37 per cent in quantity and a decrease of 25 per cent in value. In addition to the quantity sold, 51,846 gallons of mineral water was consumed in the manufacture of soft drinks. One spring active in 1917 reported no sales in 1918; another from which no report was received was omitted. No bathing establishments or resorts were reported to have been maintained.

Sources of mineral waters sold in Oklahoma in 1918.

Spring or well.	Location.			
	County.	Nearest post office.	Direction from post office.	Distance from post office.
				Miles.
Bromide Spring	Murray	Sulphur		
Everpure Well	Oklahoma	Oklahoma City	Northeast	
Guthrie Mineral Wells	Logan	Guthrie	South	(a)
Kalium Well	Comanche	Faxon	West	1½
Lewis Lithia Wells	Oklahoma	Oklahoma City		
Sparkling Water Well	Pottawatomie	Shawnee	West	1
Standard Wells	Tulsa	Tulsa	Southeast	(a)
White Sulphur Spring	Creek	Sapulpa	Southwest	(a)
Works Excelsior Mineral Well	Stephens	Comanche	do	1

a Post office at springs or springs situated in town.

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OREGON.

Returns for 1918 show a decrease of 1 per cent in quantity and 36 per cent in value of mineral waters sold in Oregon in 1918. The sales were 13,550 gallons, valued at $1,825, as compared with 13,741 gallons, valued at $2,842, in 1917. The average price per gallon declined from 21 to 13 cents. One spring which was active in 1917 and was not heard from in 1918 was omitted; thus the number of active springs was reduced from 5 to 4. Two resorts accommodating about 150 guests and three mineral-water bathing establishments were maintained. In addition to the water reported sold, 6,050 gallons was used in the manufacture of soft drinks, a decrease of 6,950 gallons from the amount used for this purpose in 1917.

Sources of mineral waters sold in Oregon in 1918.

Spring or well.	Location.			
	County.	Nearest post office.	Direction from post office.	Distance from post office.
				Miles.
Calapooya Springs	Lane	Cottage Grove	South	12
Cascade Mineral Springs	Linn	Cascadia		
Sam-O. Spring	Baker	Baker	Northeast	1½
White Pelican Spring	Klamath	Klamath Falls	East	1½

PENNSYLVANIA.

The returns from Pennsylvania indicate a decrease of 13 per cent in quantity and 16 per cent in value of mineral water sold in 1918, as compared with 1917. The price per gallon remained about the same, 9 cents. The total output was 1,400,456 gallons, valued at $123,436. The sales of table water amounted to $112,540, and $10,896 was reported from sales of medicinal water. In addition, 463,832 gallons was used in the manufacture of soft drinks, an increase as compared with 1917.

Thirty springs were active in 1918, a decrease of 11. Four springs which marketed water in 1917 were inactive in 1918; six others which were not heard from were omitted; and the output of one spring was estimated. Five resorts accommodating 745 guests and two mineral water bathing establishments were maintained.

Mineral waters sold in Pennsylvania, 1914–1918.

Year.	Commercial springs.	Quantity sold.	Value.	Average price per gallon.
		Gallons.		*Cents.*
1914	47	2,457,626	$213,752	9
1915	47	2,136,218	174,798	8
1916	42	1,671,637	145,133	9
1917	41	1,603,090	147,021	9
1918	30	1,400,456	123,436	9

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Sources of mineral waters sold in Pennsylvania in 1918.

Spring or well.	Location.			
	County.	Nearest post office.	Direction from post office.	Distance from post office.
				Miles.
Battering Ram Spring	Luzerne	Berwick	East	1½
Carnegie Alkaline Mineral Springs.	Allegheny	Carnegie		
Chadwick Mineral Well	Crawford	Cambridge Springs		
Cloverdale Well	Cumberland	Newville	Northwest	2½
Cold Spring	Lebanon	Lotell		
Dark Hollow Spring	Allegheny	Oakmont	East	1½
De Profundus Spring	Crawford	Saegerstown		
Ephrata Mountain Crystal Spring.	Lancaster	Ephrata		2
Franklin Lithia Well	Crawford	Cambridge Springs		
Glen Summit Spring	Luzerne	Wilkes-Barre	South	9
Gray Mineral Spring	Crawford	Cambridge Springs		
Great Oak Spring	Chester	Pottstown	Southwest	5
Hutchinson Spring	Lawrence	New Castle	North	5
Rural Spring	do	do	do	½
Jordan Mineral Spring	Allegheny	Presto	do	1
Juniata Springs	Blair	Altoona	do	3
Kecksburg Mineral Springs	Westmoreland	Mammoth	do	1
Keystone Spring	Bucks	Taylorsville		
Minnequa Spring	Bradford	Canton	North	3
Mount Laurel Spring	Berks	Temple	East	1
Pavilion Spring	do	Wernersville	South	1½
Polar Spring	Bucks	Morrisville	West	1
Puritas Spring	Erie	Erie		
Quaill Farm Spring	Allegheny	Bellevue		
Ross Common Springs	Monroe	Windgap	North	3
Springfield Spring	Delaware	Overbrook		
Summer Hill Spring	Allegheny	Pittsburgh	Northeast	3
Thurstons Carbonate Springs	Crawford	Meadville	East	1½
West Nanticoke Artesian Well	Luzerne	West Nanticoke		
Whannis Lithia Springs	Venango	Franklin	East	2 1/16
White Star Spring	Northampton	Easton	South	4

RHODE ISLAND.

Rhode Island in 1918 reported sales from six springs amounting to 365,705 gallons, valued at $30,729. The average price per gallon was 8 cents. The water was sold exclusively for table use, and in addition 37,833 gallons was used in the manufacture of soft drinks, as against 31,830 gallons used for this purpose in 1917. The sales in 1917, at 7 cents a gallon, amounted to 368,976 gallons, valued at $24,975. Thus there was a decrease of nearly 1 per cent in quantity and an increase of 23 per cent in value in 1918.

Sources of mineral waters sold in Rhode Island in 1918.

Spring or well.	Location.			
	County.	Nearest post office.	Direction from post office.	Distance from post office.
				Miles.
Berry Spring	Providence	Pawtucket	Southeast	1½
Girard Spring	do	do	West	3
Gladstone Spring	Washington	Narragansett Pier	Southwest	½
Holley Mineral Spring	Providence	Woonsocket		
Ochee Spring	do	Providence	West	3½
Prophet Spring	do	do	Northwest	2

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SOUTH CAROLINA.

The sales of mineral water in South Carolina during 1918 amounted to 279,300 gallons, valued at $51,198, as compared with 289,094 gallons, valued at $45,729, in 1917. These changes are equivalent to a decrease of 3 per cent in quantity and an increase of 12 per cent in value. Ninety-five per cent of the output was sold for medicinal use. One spring active in 1917 was idle in 1918; two springs idle in 1917 reported sales in 1918. One of these, Economy Spring, was formerly called White Diamond Lithia Spring. One resort accommodating 325 guests was maintained. In addition to the mineral water reported sold, 300,000 gallons was used in the manufacture of soft drinks.

Sources of mineral waters sold in South Carolina in 1918.

Spring or well.	Location.			
	County.	Nearest post office.	Direction from post office.	Distance from post office.
				Miles.
Chick Springs	Greenville	Chick Springs		
Economy Spring	York	Kings Creek	East	2½
Glendale Mineral Spring	Bamberg	Bamberg	Southwest	4
Glenn Springs	Spartanburg	Glenn Springs		
Healing Springs	Barnwell	Blackville		
Mansfield Mineral Springs	Spartanburg	Spartanburg	Northeast	4
Mertins Crystal Springs	Aiken	Augusta	do	5
Shivar Spring	Fairfield	Shelton	East	1

SOUTH DAKOTA.

Three springs in South Dakota reported sales in 1918 which amounted to 454,865 gallons, valued at $17,269, as compared with 443,167 gallons, valued at $13,545, in 1917, an increase of 3 per cent in quantity and 27 per cent in value. The average price per gallon rose from 3 to 4 cents. All but 65 gallons of this water was sold for table use, and 11,875 gallons in addition was used in the manufacture of soft drinks. No resorts or bathing establishments were maintained.

Sources of mineral waters sold in South Dakota in 1918.

Spring or well.	Location.			
	County.	Nearest post office.	Direction from post office.	Distance from post office.
				Miles.
Culbert Spring	Brown	Aberdeen	Southwest	2
Milbank Well	Grant	Milbank	North	
Spring Brook Spring	Roberts	Sisseton	Southeast	¾

TENNESSEE.

The mineral-water trade of Tennessee showed an increase in 1918 of 31 per cent in quantity and 13 per cent in value. The average price per gallon decreased for the first time in six years from 6 to 5 cents.

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The total output for 1918 was 990,027 gallons, valued at $53,367, as compared with 758,193 gallons, valued at $47,362, in 1917. The sales of medicinal waters amounted to $10,413 and of table waters to $42,954. Six springs active in 1917 reported no sales in 1918; one unreported spring was omitted; and Gibson Wells reported sales for the first time. Thus the number of active springs in 1918 was reduced to 13. Seven resorts, accommodating about 1,300 guests, were operated.

Mineral waters sold in Tennessee, 1914–1918.

Year.	Commercial springs.	Quantity sold.	Value.	Average price per gallon.
		Gallons.		*Cents.*
1914	23	943,502	$56,741	6
1915	23	703,566	39,304	6
1916	20	799,346	48,416	6
1917	19	758,193	47,362	6
1918	13	990,027	53,367	5

Sources of mineral waters sold in Tennessee in 1918.

Spring or well.	Location.			
	County.	Nearest post office.	Direction from post office.	Distance from post office.
				Miles.
Buena Vista Springs	Davidson	Nashville		
Bush Epsom Lithia Wells	do	do		
Gibson Wells	Gibson	Humboldt	Northeast	11
Horn Springs	Wilson	Hornsprings		
Lockeland Spring	Davidson	Nashville	East	3
Pioneer Springs	do	do	South	5
Red and Black Boiling Springs	Macon	Red Boiling Springs		
Rhea Springs	Rhea	Rhea Springs		
Sunrise Springs	Cheatham	Ashland City	South	2
Tate Spring	Grainger	Tate	East	1½
Thompson Spring	Davidson	Nashville		
Whittle Springs	Knox	Knoxville	North	3
Wright's Epsom Lithia Spring	Hawkins	Mooresburg	Northwest	1

TEXAS.

There was an increase in the sales of mineral waters in Texas in 1918 of about 0.6 per cent in quantity and 12 per cent in value, all of the water being reported as sold for medicinal use. The total sales amounted to 544,183 gallons, valued at $80,553. In addition, about 30,000 gallons of mineral water was consumed in the manufacture of soft drinks.

No new springs were reported. Six springs active in 1917 reported no sales for 1918; one spring idle in 1917 was active in 1918; and four springs active in 1917 were not heard from in 1918. Two resorts, accommodating about 300 guests, and one mineral-water bathing establishment were reported.

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Sources of mineral waters sold in Texas in 1918.

Spring or well.	Location.			
	County.	Nearest post office.	Direction from post office.	Distance from post office.
				Miles.
Aqua Vitae Wells	Nacogdoches	Nacogdoches		
Austin Well	Palo Pinto	Mineral Wells		
Brock's Mineral Wells	Denton	Denton	South	2½
Capps Mineral Wells	Gregg	Longview		
Crazy and Gibson Wells	Palo Pinto	Mineral Wells		
Dove Mineral Well	Wilson	Sutherland Springs		
Hefner Wells	Lamar	Blossom	West	½
Lamar Wells	Palo Pinto	Mineral Wells		
Mangum Wells	Eastland	Mangum		
Maurice Wells	do	do		
Mitchell Well		Greenville	South	2
Riviere Mineral Wells	Smith	Tyler	North	1
Roach Mineral Well	Titus	Cookville	Southwest	4
Sour Well	Hopkins	Sulphur Springs	West	¾
Texas Carlsbad Wells	Palo Pinto	Mineral Wells		
Tioga Mineral Wells	Grayson	Tioga		
Weatherby Wells	Nacogdoches	Garrison		
Wizard Wells	Jack	Wizard Wells		

VERMONT.

The mineral-water trade in Vermont in 1918 was 1 per cent greater in quantity and 3 per cent less in value than in 1917. The total sales were 95,700 gallons, valued at $17,090, as compared with 94,500 gallons, valued at $17,705 in 1917. The average price per gallon fell from 19 to 18 cents. In addition to the mineral water reported sold, about 30,000 gallons was used in the manufacture of soft drinks. Two resorts, accommodating 600 guests, and one mineral-water bathing establishment were maintained. The same springs active in 1917 reported sales for 1918.

Sources of mineral waters sold in Vermont in 1918.

Spring or well.	Location.			
	County.	Nearest post office.	Direction from post office.	Distance from post office.
				Miles.
Clarendon Nitrogen and North Springs.	Rutland	West Rutland	South	4
Cold Spring	do	Wells	East	¼
Equinox Mountain Spring	Bennington	Manchester	West	3

VIRGINIA.

Returns from Virginia show that in 1918 the sales of mineral waters in that State decreased 31 per cent in quantity and 27 per cent in value, largely on account of a decrease in the sales of medicinal water. The total output was 1,745,105 gallons, valued at $173,912, as compared with 2,518,050 gallons, valued at $237,788, in 1917. The average price rose from 9 to 10 cents per gallon. In addition to the water reported as sold 519,586 gallons was used in the manufacture of soft drinks.

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Five springs active in 1917 reported no sales in 1918; three springs active in 1917 were not heard from in 1918; two springs idle in 1917 reported sales in 1918; and one spring reported sales for the first time. Ten resorts, accommodating about 1,700 guests, and four mineral-water bathing establishments were maintained at springs.

Craig Healing Springs, Craig County, is reported in the list of active springs for the first time.

Mineral waters sold in Virginia, 1914–1918.

Year.	Commercial springs.	Quantity sold.	Value.	Average price per gallon.
		Gallons.		*Cents.*
1914	50	2,906,976	$293,512	10
1915	50	3,027,528	237,818	8
1916	50	2,313,616	248,906	11
1917	41	2,518,050	237,788	9
1918	35	1,745,105	173,912	10

Sources of mineral waters sold in Virginia in 1918.

Spring or well.	Location.			
	County.	Nearest post office.	Direction from post office.	Distance from post office.
				Miles.
Alkaline Lithia Spring	Augusta	Staunton	North	5
Alleghany Spring	Montgomery	Alleghany Springs		
Bear Lithia Spring	Rockingham	Elkton		
Beaufont Spring	Chesterfield	Richmond	South	3½
Berry Hill Mineral Spring	Culpeper	Elkwood	East	2
Blue Ridge Springs	Botetourt	Blue Ridge Springs		
Broad Rock Spring	Chesterfield	Richmond	Southeast	1½
Buckhead Springs	do	Buckhead Springs		
Buffalo Mineral Springs	Mecklenburg	Buffalo Lithia Springs		
Burnett Mineral Spring	Culpeper	Culpeper	West	6
Carter Springs	Pittsylvania	Danville	Northwest	3
Chlorinated Calcic Spring	Norfolk	Norfolk	do	3
Coppahaunk Mineral Spring	Surry	Waverly	Southwest	2
Craig Healing Springs	Craig	Newcastle		
Crockett Arsenic Lithia Springs	Montgomery	Crockett Springs		
Crystal Spring	Dinwiddie	Petersburg	Southwest	1½
Farmville Lithia Springs	Cumberland	Farmville	North	½
Fonticello Spring	Chesterfield	Richmond	Southwest	1
Granite Mineral Spring	do	do		
Harris anti-Dyspeptic Spring	Nottoway	Burkeville		
Healing Springs	Bath	Healing Springs	Southwest	½
Kayser Springs	Augusta	Staunton	do	1½
Lithia Magnesia Springs	Franklin	Rockymount	West	1
Magee Chlorinated Lithia Springs	Mecklenburg	Clarksville		
Massanetta Spring	Rockingham	Harrisonburg	East	4
Mecklenburg Mineral Spring	Mecklenburg	Chase City	South	
Mico Well	Alexandria	Alexandria	East	¼
Nye Lithia Springs	Wythe	Wytheville	do	2
Paeonian Springs	Loudoun	Paeonian Springs	South	
Pickett's Radio-active Spring	Prince Edward	Warsham	East	1½
Rockbridge Alum Springs	Rockbridge	Rockbridge Alum Springs.		
Rubino Healing Springs	Bath	Healing Springs	Southwest	½
Seawright Spring	Augusta	Fort Defiance		3
Stribling Springs	do	Mount Solon		7
Virginia Etna Springs	Roanoke	Vinton	West	¼
Wyrick Mineral Spring	Wythe	Crockett	Southwest	1

WASHINGTON.

Reports of sales of mineral waters in Washington were received from one spring only. It is called the Artesian Mineral Well, North Yakima, Yakima County.

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WEST VIRGINIA.

The output of mineral waters in West Virginia in 1918 amounted to 301,883 gallons, valued at $32,045, as compared with 156,267 gallons, valued at $37,529, in 1917. This change is equivalent to an increase of 93 per cent in quantity and a decrease of 15 per cent in value. One spring active in 1917 was not heard from in 1918; one spring active in 1917 reported no sales in 1918; two springs idle in 1917 reported sales in 1918; and one new spring was added to the list. Thus the number of active springs in 1918 was 8. Three resorts, accommodating 1,150 guests, and two mineral-water bathing establishments were operated at springs.

Sources of mineral waters sold in West Virginia in 1918.

Spring or well.	Location.			
	County.	Nearest post office.	Direction from post office.	Distance from post office.
				Miles.
Borland Mineral Springs	Wood	Willow		
Hamlett Sulphur Well	Monroe	Alderson	West	
Manacea Irondale Spring	Preston	Independence		3
Pence Spring	Summers	Pence Springs	North	¼
Saline Chalybeate and Vigora Springs.	Ohio	Wheeling	East	1
Walnut Hill Spring	Kanawha	Charleston	Northwest	1½
White Sulphur Spring	Greenbrier	White Sulphur Springs.	West	1

WISCONSIN.

The sales of mineral waters in Wisconsin increased in 1918. The total output was 6,630,725 gallons, valued at $1,193,345, as compared with 6,296,634 gallons, valued at $1,362,498, in 1917. These figures represent an increase of 5 per cent in quantity and a decrease of 12 per cent in value. The sales of table waters amounted to $1,153,608, and of medicinal waters to $39,737. The average price per gallon fell from 22 to 18 cents. In addition to the water reported as sold, 1,423,900 gallons was used in the manufacture of soft drinks. Wisconsin ranked first in total quantity and value of mineral waters sold in 1918, and second in consumption of mineral waters for the manufacture of soft drinks. One resort accommodating 1,200 guests was maintained, but no bathing establishment was operated at springs. One spring temporarily idle in 1917 was active in 1918; five springs active in 1917 reported no sales in 1918; thus the number of active springs in 1918 was 32, against 36 in 1917.

Mineral waters sold in Wisconsin, 1914–1918.

Year.	Commercial springs.	Quantity sold.	Value.	Average price per gallon.
		Gallons.		*Cents.*
1914	35	5,145,452	$588,373	11
1915	36	4,861,734	1,051,405	22
1916	36	7,696,813	1,507,679	20
1917	36	6,296,634	1,362,498	22
1918	32	6,630,725	1,193,345	18

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Sources of mineral waters sold in Wisconsin in 1918.

Spring or well.	Location.			
	County.	Nearest post office.	Direction from post office.	Distance from post office.
				Miles.
Allouez Spring	Brown	Green Bay	Southeast	1
Almanaris Spring	Waukesha	Waukesha	North	1
Arbutus Natural Mineral Spring	Oconto	Oconto	Northwest	2½
Arcadian Spring	Waukesha	Waukesha		
Bay City Springs	Ashland	Ashland	East	1½
Bethania Spring	Polk	Osceola	Southwest	1½
Bethesda Spring	Waukesha	Waukesha	do	1
Castalia Spring	Milwaukee	Elm Grove	Southeast	1
Chippewa Springs	Chippewa	Chippewa Falls	South	1
Clysmic Spring	Waukesha	Waukesha		
Crystal Spring	Sheboygan	Sheboygan	Northwest	3
Do	Waupaca	Waupaca	Southeast	1
Darlington Mineral Spring	Lafayette	Darlington	West	½
Elysian Mineral Well	Crawford	Prairie du Chien	Southwest	
Famous Spring	Waukesha	Menomonee Falls	South	
Glenn Rock Mineral Spring	do	Waukesha		
High Rock Spring	do	do		
Hydrox Spring	Jefferson	Palmyra		
Lebenswasser Spring	Brown	Green Bay		
Nee-Ska-Ra Spring	Milwaukee	Wauwatosa	Northeast	1
Roxo Spring	Waukesha	Waukesha	East	1
Salvartor Spring	Brown	Green Bay		
Sheboygan Spring	Sheboygan	Sheboygan	Northwest	½
Sheridan Mineral Spring	Walworth	Lake Geneva	Northeast	1½
Silurian and Waukesha AAAA Springs.	Waukesha	Waukesha	East	
Silver Springs	Dane	Madison	South	3
Soda Lithia Spring	Waukesha	Menomonee Falls	do	4
Solon Springs	Douglas	Solon Springs	do	1
Sulphur Mineral Springs	Winnebago	Oshkosh	North	3
Waukesha Fox Head Spring	Waukesha	Waukesha	South	¾
White Rock Spring	do	do		1½
Wilnette Spring	Racine	Racine	West	1½

WYOMING.

Sales from 4 springs in Wyoming in 1918 amounted to 41,335 gallons, valued at $5,513, or a decrease in quantity of 23 per cent and in value of 30 per cent, as compared with the output in 1917. One small resort and two mineral-water bathing establishments were operated, and about 500 gallons of mineral water also was used in the manufacture of soft drinks.

Sources of mineral waters sold in Wyoming in 1918.

Spring or well.	Location.			
	County.	Nearest post office.	Direction from post office.	Distance from post office.
				Miles.
Big Horn Hot Springs	Hot Springs	Thermopolis		
De Maris Spring	Park	Cody	West	3
Paulson Well	Carbon	Saratoga	East	
Skyrok Water	Laramie	Granite Canon		

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ARCHITECTURAL CONCRETE STONE AND CONCRETE BLOCKS IN 1917 AND 1918.[1]

By G. F. Loughlin.

INTRODUCTION.

In 1917, having received numerous requests for statistical information on the production of artificial stone, the United States Geological Survey undertook to canvass the producers and to issue a report on artificial stone as a supplement to the regular annual reports on natural stone, cement, and sand and gravel. This work had to be carried on in odd moments, and owing to lack of office force and to the many pressing demands on the Survey for special war information, compilation of the figures for 1917 could not be completed until 1919. It was therefore decided to publish the reports for 1917 and 1918 together.

Preparation of the figures for 1918 has also been greatly retarded by pressure of work which had priority, by the extra work involved in the systematizing of data obtained for the first time, and by the need for sending repeated requests to producers who failed to reply. In 1917 requests were sent to 3,200 firms, of which only 1,295 made reply. Several of these firms reported that they were out of business. In 1918 requests were sent to 2,830 firms, and when replies were not received within a reasonable time, second and even third requests were sent. To one or another of these three requests 1,962 firms made reply, and the figures for 1918 are therefore much more accurate than those for 1917, especially as to concrete blocks and miscellaneous products. The figures for architectural concrete stone for the two years are believed, however, to be essentially accurate. According to the replies received, 609 firms were active in 1917 and 920 in 1918; of these, 62 firms in 1917 and 42 firms in 1918 reported sales of architectural concrete stone.

On the blanks sent to producers the term "artificial stone" was used, but inasmuch as the products represented are all ordinary or special concrete mixtures of Portland cement, with different aggregates, and as at least some of the producers are chartered under State laws as "concrete-stone manufacturers," their suggestion to replace the terms "artificial stone" by "concrete stone" has been adopted. Some producers, however, specifically advertise "artificial" or "imitation" stone.

The product of principal interest to architects and to the building industry in general is that which serves the same purpose as natural cut stone and terra cotta in the facings and trimmings of the larger and more elaborate buildings. This product is designated "architectural concrete stone." A few manufacturers reported the production of "Mycenian marble," "Scagliola," "staff," and other

[1] The statistics in this report were compiled by Miss A. E. Davis, of the United States Geological Survey.

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gypsum products; but as the quantity of these can be estimated from the combined domestic production and imports of Keene's cement, no effort was made to include them in this report. Most producers reported "concrete blocks" or "concrete bricks"—products used principally for foundations and for facings and trimmings of private dwellings and other small buildings and serving the same purpose as rubble stone, brick, and monolithic concrete. Several firms reported one or more other products, such as silo blocks and sewer blocks, but these firms were so widely scattered that only the totals for the country are published. A few producers reported "art work" of different kinds, but this class of products is too incompletely represented to justify publication of the totals compiled.

In the following tables the figures are shown in as much detail as possible without disclosing individual returns.

Concrete stone produced in the United States in 1917.

State.	Architectural stone.		Concrete blocks and bricks.		Total value.
	Quantity.	Value.	Quantity.	Value.	
New England States:	*Cubic feet.*		*Number.*		
Connecticut	103,600	$185,250	(a)	(a)	[a] $185,250
Maine			[a] 51,361	[a] 9,743	[a] 9,743
Massachusetts	273,755	365,824	142,757	15,107	380,931
New Hampshire			(a)	(a)	(a)
	377,355	551,074	194,118	24,850	575,924
Middle Atlantic States:					
Maryland			78,100	11,775	11,775
New Jersey	60,000	70,500	259,282	36,088	106,588
New York	141,448	280,861	717,733	92,222	373,083
Pennsylvania	54,115	67,230	149,317	29,007	96,237
	255,563	418,591	1,204,432	169,092	587,683
Southeastern States:					
Florida	37,500	15,825	53,963	5,175	21,000
Georgia	(b)	(b)			(b)
Kentucky			38,500	7,465	7,465
Tennessee			53,350	11,500	11,500
Virginia			(a)	(a)	(a)
West Virginia	[b] 41,800	[b] 32,400	[a] 96,100	[a] 15,775	[a b] 48,175
	79,300	48,225	241,913	39,915	88,140
East Central States:					
Illinois	(b)	(b)	889,242	112,245	[b] 112,245
Indiana	(b)	(b)	1,404,452	172,999	[b] 172,999
Michigan	[b] 108,207	[b] 102,430	576,581	86,572	[b] 189,002
Ohio	311,130	167,408	1,926,026	291,579	458,987
Wisconsin			712,760	87,046	87,046
	419,337	269,838	5,509,061	750,441	1,020,279
West Central and South Central States:					
Arkansas	(b)	(b)	(a)	(a)	(a b)
Iowa	(b)	(b)	1,407,824	193,480	[b] 193,480
Kansas	[b] 30,600	[b] 45,533	339,135	36,357	[b] 81,890
Minnesota	[b] 7,637	[b] 5,537	365,942	60,715	[b] 66,252
Missouri	[b] 97,000	[b] 134,750	[a] 98,551	[a] 15,577	[a b] 150,327
Nebraska	(b)	(b)	1,646,955	204,949	[b] 204,949
Oklahoma			122,790	12,787	12,787
South Dakota			86,350	13,360	13,360
Texas	96,399	79,150	68,021	8,922	88,072
	231,636	264,970	4,135,568	551,147	816,117
Western States:					
California	33,769	25,750	(a)	(a)	[a] 25,750
Colorado	(b)	(b)	47,700	2,661	[b] 2,661
Montana	[b] 16,456	[b] 1,110			[b] 1,110
Oregon	(b)	(b)	[a] 57,000	[a] 5,650	[a b] 5,650
Utah			26,307	4,623	4,623
	50,225	26,860	131,007	12,934	39,794
Grand total	1,413,416	1,579,558	11,416,099	1,548,379	3,127,937

[a] Concrete blocks for Connecticut and New Hampshire are included under Maine, for Virginia under West Virginia, for Arkansas under Missouri, for California under Oregon.

[b] Architectural stone for Georgia is included under West Virginia, for Illinois and Indiana under Michigan, for Arkansas under Missouri, for Iowa under Minnesota, for Nebraska under Kansas, for Colorado and Oregon under Montana.

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Concrete stone produced in the United States in 1918.

State.	Architectural stone.		Concrete blocks and bricks.		Total value.
	Quantity.	Value.	Quantity.	Value.	
New England States:	*Cubic feet.*		*Number.*		
Connecticut	[a] 184,039	[a] $293,735	[b]	[b]	[a b] $293,735
Maine	[a]	[a]	185,600	$53,770	[a] 53,770
Massachusetts	[a]	[a]	1,563,789	19,477	[a] 19,477
New Hampshire			[b]	[b]	[b]
Rhode Island			[b] 41,829	[b] 14,367	[b] 14,367
	184,039	293,735	1,791,218	87,614	381,349
Middle Atlantic States:					
Delaware			[b]	[b]	[b]
Maryland			[b] 71,977	[b] 15,075	[b] 15,075
New Jersey	9,000	15,500	417,914	76,553	92,053
New York	120,166	324,100	1,171,198	153,604	477,704
Pennsylvania	33,600	43,220	327,175	72,196	115,416
	162,766	382,820	1,988,264	317,428	700,248
Southeastern States:					
Florida	[a]	[a]	235,447	24,045	[a] 24,045
Georgia			8,175	2,152	2,152
Kentucky			38,258	7,134	7,134
Tennessee			28,500	7,380	7,380
Virginia			40,218	6,500	6,500
West Virginia	[a] 45,150	[a] 90,113	42,700	9,830	[a] 99,943
	45,150	90,113	393,298	57,041	147,154
East Central States:					
Illinois	[a]	[a]	1,633,374	254,252	[a] 254,252
Indiana			1,657,715	211,499	211,499
Michigan	[a]	[a]	1,097,799	143,475	[a] 143,475
Ohio	[a] 74,500	[a] 83,250	2,232,583	377,070	[a] 460,320
Wisconsin			833,091	84,786	84,786
	74,500	83,250	7,454,562	1,071,082	1,154,332
West Central and South Central States:					
Arkansas			48,800	7,188	7,188
Iowa			2,401,772	225,054	225,054
Kansas	[a]	[a]	312,810	38,228	[a] 38,228
Louisiana			[b]	[b]	[b]
Minnesota			1,182,544	164,882	164,882
Missouri	[a] 58,500	[a] 95,375	200,574	22,979	[a] 118,354
Nebraska			1,909,864	250,326	250,326
North Dakota	[a]	[a]	[b]	[b]	[a b]
Oklahoma			140,300	16,786	16,786
South Dakota			[b] 57,665	[b] 11,664	[b] 11,664
Texas	74,449	85,306	[b] 82,393	[b] 15,714	[b] 101,020
	132,949	180,681	6,336,722	752,821	933,502
Western States:					
California	14,160	15,545	[b] 56,405	[b] 4,283	[b] 19,828
Colorado	[a]	[a]	15,223	3,856	[a] 3,856
Montana	[a] 12,261	[a] 26,373			[a] 26,373
Nevada			[b]	[b]	[b]
Oregon	[a]	[a]	[b]	[b]	[a b]
Utah			[b] 26,985	[b] 5,635	[b] 5,635
Washington			[b]	[b]	[b]
	26,421	41,918	98,613	13,774	55,692
Grand total	625,825	1,072,517	18,062,677	2,299,760	3,372,277
Percentage of increase or decrease in 1918	−56	−32	+58	+49	+8

[a] Architectural stone for Maine and Massachusetts is included under Connecticut, for Florida under West Virginia, for Illinois and Michigan under Ohio, for Kansas and North Dakota under Missouri, for Colorado and Oregon under Montana.

[b] Concrete blocks and bricks for Connecticut and New Hampshire are included under Rhode Island, for Delaware under Maryland, for Louisiana under Texas, for North Dakota under South Dakota, for Oregon under California, for Nevada and Washington under Utah.

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ARCHITECTURAL CONCRETE STONE.

The quantity and value of architectural stone produced in 1917 and 1918 are shown in the first two columns of the foregoing tables. According to these tables the quantity decreased from 1,413,416 cubic feet in 1917 to 625,825 cubic feet in 1918—a decline of 56 per cent. Owing to the higher prices in 1918, the corresponding decrease in values was only 32 per cent. The value is that of the product f. o. b. factory.

The New England States, second in quantity of production in 1917, were first in 1918, although their production decreased more than one-half. The Middle Atlantic States, third in 1917, were second in 1918, their quantity decreasing more than one-third. The East Central States, first in 1917, were only fourth in 1918, Ohio's great decrease accounting for the change. These three districts produced 74 per cent of the total quantity in 1917 and 67 per cent in 1918. The other three districts decreased in production considerably in 1918, though in less proportion than the three leading districts.

The output was everywhere sold for comparatively local consumption. A number of producers sold their product in several cities within their own States and a few shipped to neighboring States. One producer in Connecticut reported his product as being shipped to New York City, Boston, Philadelphia, and Washington; another in Connecticut reported shipments to territory east of Buffalo; one in Massachusetts, to different New England States; one in Missouri, to Oklahoma, Texas, and Kansas; another in Missouri, to Kansas, Texas, Oklahoma, and Arkansas; and one in Texas, to Oklahoma, Arkansas, Louisiana, and New Mexico.

The average price per cubic foot was $1.12 in 1917 and $1.71 in 1918. The range in price was wide. Some products were not much more than concrete blocks prepared with unusual care and sold for as little as 15 cents a cubic foot in 1917 and 22 cents in 1918, and there was no sharp line of demarcation between these prices and those of ordinary concrete blocks. Others, of ornamental character and prepared in special molds, brought as much as $10 a cubic foot. The quantity sold for extraordinarily high prices, however, was far too small to affect the average price appreciably. One producer in New England manufactured only ornamental modeled architectural casts at $5 a cubic foot. A producer in the West, whose price in 1917 was $4 a cubic foot, stated that most of his product was more decorative than in other years, and that the average price was therefore twice as much. Another western producer reported "hand-finished artificial stone" from $1.50 to $3 a cubic foot. Prices reported by other important producers ranged from 50 cents to $2.50 a cubic foot.

The aggregates reported as used in 1917 and 1918 are listed in the table on pages 538–539. This table shows that relatively few manufacturers use granite, marble, or trap rock (diabase and basalt) to produce special textural effects in imitation of marble and granite. Some of those using miscellaneous aggregates, however, may produce similar results. A large number may manufacture products resembling sandstones and limestone in general appearance.

Business conditions during 1917 and 1918 affected producers of architectural concrete stone much the same as they affected producers of natural building stone. Labor and materials were both scarce

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and much higher in price than before, and these conditions, together with war restrictions on transportation of "less essential materials," discouraged purchasers. Many producers reported that the war had put them temporarily or permanently out of business. The total production for each of these years is far below normal, therefore, but its proportion to the production of other building materials has probably not changed significantly.

CONCRETE BLOCKS.

The apparent great increase in production of ordinary concrete blocks—from approximately 11,416,000, valued at $1,548,379, in 1917 to approximately 18,063,000, valued at $2,299,760, in 1918—is largely if not wholly due to the more complete returns made in 1918. Even a small actual increase of building material would have been abnormal in 1918. There was little change in rank, however, among the six districts designated—New England, with an apparent increase of ninefold in quantity, gaining fourth place in 1918 at the expense of the Southeastern States, whose apparent increase was somewhat more than 60 per cent. The East Central and West Central districts were by far the most productive in each year, and each recorded an apparent increase in 1918. Only the Western States showed a decrease in quantity. The apparent gain in value was enough to give all sections except New England a recorded gain in total concrete products.

Individual reports regarding business conditions for concrete blocks were for the most part similar to those given for architectural concrete stone. A few producers, however, were favored by contracts to furnish blocks for Government housing projects.

The average price was 13.6 cents a block in 1917 and only 12.7 cents in 1918. In 1917 prices mostly range from 8 to 12 cents a block but in some places were as high as 17 and even 20 cents. In 1918 the prices of blocks were commonly from 12 to 35 cents, but the price of concrete bricks was commonly $12 a thousand, which accounts for the lower average price recorded for 1918. The different sizes of blocks and bricks and the failure of several producers to state sizes made it impossible to reduce the quantity of blocks and bricks to definite units, the only means of showing their actual and relative importance in the building industry. It is hoped that this will be possible in future reports.

MISCELLANEOUS PRODUCTS.

Reports of products of this class, other than architectural concrete stone and concrete blocks, were too scattered in 1917 to justify a statement of the quantities sold and their value. In 1918 also the reports were so scattered that tabulation by States was impracticable, but the totals for the entire country were as follows:

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Miscellaneous concrete products sold in 1918.[a]

	Number.	Value.
Silo blocks, staves, and circles	183,004	$45,325
Sidewalk blocks and tile	67,171	14,567
Sewer blocks	67,000	8,040
Cistern blocks or tile	15,474	1,288
Well blocks, curbing, and circles	62,784	11,499
Corn cribs and crib piers	30,991	5,519
	426,424	86,238

[a] A very small production of draintile is omitted.

Here again failure of producers to state size or dimensions of the products lessens the significance of the figures for quantity. Of the 34 producers who stated the kinds of aggregates used in these products, all but two used sand and gravel; of these two one used granite screenings and the other sand and limestone. The three leading States in these products and the values of their outputs were Minnesota, $33,309; Iowa, $12,016; and Wisconsin, $12,407.

AGGREGATES.

Number of producers of concrete stone, blocks, and bricks in the United States reporting the aggregates used, 1917 and 1918.

State.	Sand.	Gravel.	Granite.	Marble.	Trap rock.	Lime-stone.	Mis-cella-neous.
1917.							
New England States:							
Connecticut	.....	.....	3	3	3	.....	.....
Maine	5	5	.....	.....	.....	.....	1
Massachusetts	5	3	6	4	1	1	1
New Hampshire	1	1	.....	.....	.....	.....	.....
	11	9	9	7	4	1	2
Middle Atlantic States:							
Maryland	1	1	1	1	.....	1	1
New Jersey	8	4	1	3	3	.....	5
New York	8	10	1	4	1	9	3
Pennsylvania	9	9	.....	.....	.....	4	4
	26	24	3	8	4	14	13
Southeastern States:							
Florida	2	2	.....	.....	.....	1	.....
Georgia	1	1	.....	.....	.....	.....	1
Kentucky	5	4	.....	.....	.....	1	1
Tennessee	.....	.....	1	.....	.....	3	1
Virginia	2	2	.....	.....	.....	.....	.....
West Virginia	2	2	.....	1	.....	2	2
	12	11	1	1	0	7	5
East Central States:							
Illinois	48	41	2	.....	.....	20	12
Indiana	37	35	.....	.....	.....	5	.....
Michigan	15	15	3	1	.....	1	.....
Ohio	30	27	4	2	.....	23	4
Wisconsin	20	20	1	.....	.....	3	.....
	150	138	10	3	0	52	16
West Central and South Central States:							
Arkansas	2	1	.....	.....	1	.....	.....
Iowa	46	46	2	.....	.....	2	.....
Kansas	14	13	.....	.....	.....	2	4
Minnesota	10	12	1	.....	1	.....	.....
Missouri	8	6	.....	1	.....	1	2
Nebraska	20	20	.....	.....	.....	1	1
Oklahoma	6	6	.....	.....	.....	1	.....
South Dakota	3	2	1	.....	.....	1	.....
Texas	4	4	.....	.....	.....	4	1
	113	110	4	1	2	12	8

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Number of producers of concrete stone, blocks, and bricks in the United States reporting the aggregates used, 1917 and 1918—Continued.

State.	Sand.	Gravel.	Granite.	Marble.	Trap rock.	Lime-stone.	Mis-cella-neous.
1917.							
Western States:							
California	1	1					
Colorado	2	1	1	1			
Montana				1			
Oregon	1		1				
Utah	2	2	1				
	6	4	3	2	0	0	0
Grand total, 1917	318	296	30	22	10	86	44
1918.							
New England States:							
Connecticut		1			2		
Maine	5	5	1	1			
Massachusetts	5	4	4	3			1
New Hampshire	1	1					
Rhode Island			1				
	11	11	6	4	2		1
Middle Atlantic States:							
Delaware	1	1					
Maryland	1	1	1				1
New Jersey	11	10		1	2		2
New York	18	18	3	7	1	6	2
Pennsylvania	15	14				4	2
	46	44	4	8	3	10	7
Southeastern States:							
Florida	2	1	1			1	2
Georgia	1	1					
Kentucky	4	5				1	
Tennessee	1	1				2	
Virginia	1	1				2	
West Virginia	2	2		1			
	11	11	1	1		6	2
East Central States:							
Illinois	92	82	3	1		21	12
Indiana	61	60				4	2
Michigan	27	29	2			2	
Ohio	65	57	2			34	2
Wisconsin	35	35					
	280	263	7	1		61	16
West Central and South Central States:							
Arkansas	4	2					2
Iowa	72	72	2			1	1
Kansas	10	10				3	1
Louisiana	1	1					
Minnesota	29	28	1	1	1	2	
Missouri	11	9				3	3
Nebraska	37	35				1	1
North Dakota	2	2					
Oklahoma	6	6				1	
South Dakota	2	1	2				1
Texas [a]							
	174	166	5	1	1	11	9
Western States:							
California	2	2	2	1			
Colorado	2	1		1			
Montana				1			
Nevada [a]							
Oregon [a]							
Utah	1	1	1				
Washington	1	1					
	6	5	3	3			
Grand total, 1918	528	500	26	18	6	88	35

[a] Aggregates not reported from Texas, Nevada, and Oregon.

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The marked increase in the number of firms reporting the use of sand and gravel is due to the more complete returns in 1918. The decrease in the number using granite, marble, and trap rock (basalt or diabase) reflects the decrease in production of architectural stone. The great preponderance of gravel over the other coarse aggregates is especially striking, and the districts where it is most used are those which lead in output of concrete blocks. Granite, marble, and trap rock are relatively most used in New England, the leading district in output of architectural concrete stone. Granite, largely for facing, is also much used in the East Central States and marble in the Middle Atlantic States. Limestone is mostly used in the East Central States. Miscellaneous aggregates include "flint" and "chats" (tailings from zinc mines, mostly in the Joplin region, Mo.), slag screenings, cinders, and unnamed crushed stone. One producer reported "coquina shell and beach sand." Feldspar and mica, derived from coarse-grained granite or pegmatite and used to face blocks imitating granite, are included with granite.

It would be interesting to know what proportion of the Portland cement, sand, gravel, and crushed stone produced during 1918 entered into the different products considered in this report, but inadequacy of the statements of quantity and uncertainty as to the proportions of cement and aggregate used make even a rough estimate impracticable. If this first report on the production of concrete stone and related products proves to be of sufficient interest and usefulness to the building industry, an effort will be made to obtain such additional information.

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STRONTIUM.

By GEORGE W. STOSE.

GENERAL REVIEW OF THE INDUSTRY.

The strontium industry in the United States, which suddenly sprang into importance at the beginning of the European war, seems to have reached its climax in 1918. Prior to 1915 the consumption of strontium in this country, so far as the records of the United States Geological Survey show, was small and its ores had been mined at only a few places in the country and in very small quantities. Until 1915 strontium was used chiefly in the manufacture of red fire in pyrotechnics and in railroad flares and fusees, but during the European war it found a larger and wider field of usefulness. Not only was it employed in night signals at the military front and at sea, but the congestion of freight in our own country and the need of every precaution in safeguarding the shipments of war materials greatly increased the practice of railroad signaling by fusees and flares. Whereas 2,000 short tons of crude ore was sufficient to meet the annual requirements before the war, it is estimated that about 4,000 tons was used in 1918.

For 20 years prior to 1915 the value of strontium salts imported averaged about $450 a year, and in 1914 it amounted to only $1,016. The imports gradually increased in the following years and the value reached $23,216 in 1917. This very marked increase resulted in part from the higher price of the product, but largely from an increased demand for the material in anticipation of future requirements, especially if war activities should cut off the foreign supply. Interest in the domestic deposits of strontium ore reflected this attempt at preparedness, and early in 1916 deposits in California and Arizona were mined and strontium ore was shipped to two manufacturing plants in southern California which began to make strontium nitrate. In the later part of 1916 another manufacturing plant began making strontium salts at Seattle, Wash., using ore mined in that State. At the end of 1916 the British Government placed an embargo on all strontium compounds, but its effect was not felt at once in the United States, for the imports of strontium salts greatly increased in the first half of 1917. In the last half of the year, however, the imports were relatively low, and in 1918 their value dropped to less than $2,500. Not only did the imports of strontium salts decline, but the production of crude strontium ores in the United States also fell off in 1918 to a few hundred pounds. The manufacture of strontium salts, on the other hand, was greatly increased during 1918, the manufacturing plants evidently using stocks of both foreign and domestic crude ore purchased in previous years.

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It is impossible at this time to predict the future of the strontium industry in this country. The production of strontium salts seems permanently established in several plants located in the Eastern States, but these plants will probably depend for their supply of crude ore chiefly on imports from England because of the large and accessible deposits that occur there and the cheapness of ocean transportation as compared with rail freight rates from the Western States, where the known workable deposits of this country occur. The production of strontium salts at three manufacturing plants in Pacific Coast States in 1916 and 1917 was temporary, for the plants have closed down and the mining of crude ore in two of these States has for the present ceased.

PRODUCTION OF CRUDE ORE.

The production of crude strontium ore in the United States in 1918 apparently was very small. The following table permits comparison with the production of previous years:

Crude strontium ores mined and sold in the United States, 1916–1918, in short tons.

Mineral.	1916	1917	1918
Celestite	240	3,630	0
Strontianite	10	405	400

No ore was mined in 1915. The ore mined during 1916, 1917, and 1918 came chiefly from California, but some came from Texas, Arizona, and Washington. The average price received at the mines for celestite in 1917 was $21.75 a ton, and for strontianite $38.15. The price received for strontianite increased to $50 a ton in 1918.

PRODUCTION OF STRONTIUM SALTS.

Three companies in the United States reported the manufacture of strontium salts from crude ore during 1918. Strontium nitrate was the chief product made, but a considerable part of the product was carbonate. Small quantities of chloride and oxalate also were manufactured. The production of strontium nitrate, carbonate, chloride, and oxalate in 1916 was 2,006,000 pounds; in 1917, 2,499,676 pounds; and in 1918, 4,927,000 pounds.

IMPORTS.

The only crude strontium mineral reported as imported in 1918 was celestite, all of which came from England. If the mineral strontianite was imported, it was not separately reported but was included with manufactured strontium carbonate and other salts by the Bureau of Foreign and Domestic Commerce. The quantity of celestite reported as having been imported during the last three years has averaged approximately 2,100 short tons a year. The quantity received in 1917 was about 1,700 tons and in 1918 it exceeded 2,600 tons.

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Value of strontium carbonate, oxide, and protoxide[1] imported into the United States, 1895–1918.

1895–1913 (average)	$447	1916	$11,049
1914	1,016	1917	23,216
1915	6,411	1918	[2] 2,459

The increase in the value of the imports for 1916 and 1917 was only in part due to the increased quantities imported, for the price of the products also increased greatly, as is shown in the table of prices given below. However, the value of the imports for 1917 was greatly in excess of that of any previous year. The marked decrease in imports in 1918 was due largely to the embargo placed on strontium salts during the European war.

The following table shows the marked change in prices of strontium carbonate and strontium nitrate quoted in New York:

Prices of strontium nitrate and strontium carbonate[a] in New York, 1914–1918, in cents per pound.

Salt.	1914	1915	1916	1917	1918
Strontium nitrate	7½–8	15–17	22–23	40–45	25–30
Strontium carbonate:					
Technical	(b)	(b)	(b)	(b)	40–45
Chemically pure	(b)	(b)	(b)	(b)	55–60

[a] Oil, Drug, and Paint Reporter Yearbook, 1918.
[b] Not quoted prior to 1918.

The decrease in the price of nitrate in 1918 practically to the price which prevailed in 1916 was apparently due to control by the Government during the war.

The following price list of salts of strontium, most of which are used largely by druggists and the medical profession, is of less interest to the producer of crude strontium ore because only a few of these salts are made direct from crude ore, the others being secondary salts made from the primary salts.

Price list of strontium salts.[3]

	Per pound.		Per pound.
Acetate, granular	$1.30	Hydroxide, powder	$1.15
Arsenite, powder	2.75	Iodide, granular	3.65
Bromide, crystalline and granular	.96	Lactate, granular, powder	2.45
Bromide, dried, powder	1.37	Nitrate, granular	.47
Carbonate, precipitate, technical	.50	Nitrate, granular, chemically pure	.70
Carbonate, pure, powder	.70	Oxalate, powder	2.00
Chloride, granular	.45	Peroxide (dioxide), powder	2.60
Chloride, dried, powder	.78	Phosphate, powder	1.25
Chloride, crystalline, chemically pure	.65	Salicylate, powder	1.25
Formate, granular	2.00	Salicylate, from oil, powder	5.20
		Sulphate, powder	.60
		Sulphide, powder	1.10

[1] Value of "oxide of strontium, protoxide of strontium, and strontianite or mineral carbonate of strontium" imported for consumption into the United States, compiled from the records of the Bureau of Foreign and Domestic Commerce.
[2] This figure seems in error, as the value given for the fourth quarter ($356) does not harmonize with the quantity reported to have been imported (185,920 pounds).
[3] Powers, Weightman & Rosengarten Co., Philadelphia, price list, February 1, 1918.

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USES AND MARKET.

Strontium is used in the form of its salts in several industries, especially in the manufacture of fireworks, drugs, and medicine. The principal salts manufactured in the United States in 1918 were strontium nitrate (SrN_2O_6) and strontium carbonate ($SrCO_3$), which are used chiefly in the production of red fire or light in pyrotechnics, flares, fusees, signal shells, and signal lights. Small quantities of chloride and oxalate were reported manufactured from crude ore in 1918. Many other salts were probably manufactured, but mostly as secondary products from the primary salts above mentioned. The acetate, lactate, bromide, iodide, arsenide, phosphate, and other salts of strontium are used in drugs and medicine. In Europe large quantities of oxide and hydroxide of strontium are used in refining beet sugar, but this process is not at present employed in the United States. A small quantity of strontium is alloyed with copper in making castings to free them of blowholes caused by included gases.

Fireworks and signal lights are manufactured in the United States almost exclusively near the Atlantic seaboard, and the demand for crude ore is therefore in the Eastern States. It has been difficult, consequently, to find a market for the domestic strontium ore, the workable deposits of which have so far been found only in the far West and which can not in normal times compete in price with the celestite obtained from England because of high freight charges unless it is protected by a tariff. During the war, however, some western ore was shipped to eastern factories.

DEPOSITS OF STRONTIUM ORES IN THE UNITED STATES.

The known workable deposits of strontium ore in this country are in Arizona, California, Texas, Utah, and Washington. Other deposits of doubtful value occur in several other of the Western States and in a few States east of Mississippi River. Most of these have been described in some detail by James M. Hill in Mineral Resources of the United States, 1916, Part II, to which the reader is referred. New finds have been reported as follows:

Utah, 25 miles southeast of the town of Green River, Grand County. J. T. Pardee, geologist, of the United States Geological Survey, reports that at this place celestite forms lenticular beds 6 inches thick associated with gypsum and limestone in the middle of the St. Elmo formation at the Colorado Fuel & Iron Co.'s manganese mine. Samples of the mineral are of excellent grade.

Nevada, 7½ miles south of Goldfield. Large deposits of strontianite are reported to have been discovered by G. L. Diffenbaugh, of Goldfield. The samples of the mineral sent to the Geological Survey, however, were largely calcite.

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ASBESTOS.

By J. S. Diller.

DOMESTIC OUTPUT.

The asbestos mined and sold in the United States in 1918 amounted to 1,002 short tons, valued at $124,687, about 60 per cent of the quantity and 25 per cent of the value of the product marketed in 1917, which was 1,683 short tons, valued at $506,056. Although there was a decline in both total quantity and value in 1918, there was an increase in the unit value of several grades. The lowest grade sold for about $15 a ton in both years, but good spinning grades which brought $500 a ton in 1917 were sold for about 20 per cent more in 1918. In States that reported sales in both years declines in output were shown in all grades except that from Maryland, which is used for chemical filters, but the decline in relative quantity produced was greatest in the spinning grades. However, the proportion of spinning fiber to lower grades produced in the United States is still much higher than in Canada. The demand for asbestos was increased by the war, but asbestos was not classed in the United States as a war mineral, and its production and distribution were delayed by embargoes and other unfavorable conditions. Six States produced asbestos in 1918—Arizona, California, Georgia, Maryland, North Carolina, and Oregon. Georgia was the largest producer, yielding, however, only low-grade fiber; North Carolina ranked next, also producing low-grade fiber; California ranked third, producing a better grade of mill fiber; and Arizona ranked fourth, with five more or less active producers, whose output is chiefly spinning fiber.

The principal feature of the asbestos industry in 1918 was the decline in production notwithstanding the increased demand and higher prices, as compared with those of 1917. This condition was due to the war and resulted from the scarcity of labor and the restraints of trade.

Domestic asbestos marketed in the United States, 1913–1918.

Year.	Quantity (short tons).	Value.	Year.	Quantity (short tons.)	Value.
1913	1,100	$11,000	1916	1,479	$448,214
1914	1,247	18,985	1917	1,683	506,056
1915	1,731	76,952	1918	1,002	124,687

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VARIETIES AND TYPES OF ASBESTOS.

The most important characteristics of asbestos are fibrous structure, tensile strength, and resistance to heat. It will not burn and is an excellent material for protection from fire. Being a slow conductor of heat, it is used to conserve heat by preventing radiation, especially about steam pipes and boilers.

Commercially the name asbestos is used to include all varieties of minerals that are so fibrous as to be thereby rendered useful. The same minerals occur also in massive nonfibrous varieties, each known by a distinctive name. Strictly speaking asbestos is fibrous amphibole, although by far the greater portion of the asbestos of commerce is fibrous serpentine, which is properly called chrysotile. Amphibole asbestos was produced in Maryland, Georgia, and North Carolina in 1918; serpentine asbestos in the Western States.

There are three structural types of asbestos—cross fiber, slip fiber, and mass fiber. Cross-fiber asbestos occurs in veins, and the fiber runs across the veins. This type is well illustrated by the veins of asbestos (chrysotile) in the altered peridotite of Thetford, Canada, and also by similar veins with serpentine in certain limestones of Arizona. This is the most abundant type, especially of chrysotile, yielding by far the greater portion of all grades of commercial fiber.

Slip-fiber asbestos occurs in planes along which the rocks have slipped against each other and given direction to the fiber. The fiber lies parallel to the slipping planes and is commonly some variety of amphibole. It yields a relatively small quantity of commercial asbestos.

Mass-fiber asbestos is rock wholly made up of irregularly arranged bundles of fibrous amphibole. The asbestos of this type is generally brittle and of low grade. It is well illustrated by the deposits mined in the Sall Mountain region of Georgia.

ASBESTOS IN THE UNITED STATES.

ARIZONA.

Chrysotile asbestos was discovered in the Grand Canyon of Arizona about 1900. The Hance Asbestos Co. was formed and brought this remarkable occurrence to public attention. It crops out on both sides of the Grand Canyon, but especially on the north side opposite Grand View. Joseph Hyde Pratt, of the United States Geological Survey, examined the deposits and described them in Mineral Resources for 1904, pages 17–20. Some years later W. W. Bass reported similar deposits in the Grand Canyon 20 miles west of Grand View. The Bass deposits are briefly described in Mineral Resources for 1907, pages 12–13, and also by L. F. Noble in United States Geological Survey Bulletin 549, pages 58–59, 1914.

At both localities in the Grand Canyon asbestos occurs in cross-fiber veins that lie with serpentine in limestone approximately parallel to its stratification and within a short distance of its contact with intruded diabase. A small quantity of asbestos has been mined at each locality in the Grand Canyon, but production has not been maintained, chiefly on account of the cost of mining and of getting the product to market.

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A chemical analysis of the Grand View asbestos was made by the Geological Survey in 1912, and attention was called to its remarkably low content of iron, which renders it especially valuable for electrical insulation.

In 1903 a deposit of chrysotile was found in southern Arizona, at the head of Pinto Creek, 23 miles west of Globe, where M. L. Shackelford located claims. The asbestos is said to be of fine quality, and fibers are said to range from a fraction of an inch to 2 or 3 inches in length. No development work or production of asbestos has been reported from this locality.

In 1913 Fred Patee informed the Geological Survey of a new locality of chrysotile in Arizona, on Ash Creek, about 40 miles northeast of Globe. The writer visited the locality under the guidance of Mr. West, one of the locators, and published an account of the deposit in Mineral Resources for 1913, part 2, pages 342–347. The writer visited the locality again in 1917 and in 1919 and found active asbestos mining in an area about 60 miles in length from northwest to southeast and 25 miles in width. He examined that part of the asbestos field lying west of the San Carlos and Apache Indian reservations, where mining operations were carried on by the Arizona Asbestos Association on Ash Creek, by the Penn Asbestos Mining Co. and the Colorado-Arizona Mining Co. just south of Salt River, by the American Ores & Asbestos Co. at the head of Pocket Creek in the Sierra Ancha, at the Roberts mine on Reynolds Creek, at the Sloane mine on the slope east toward Cherry Creek, and by the Alene Asbestos Association on a branch of Canyon Creek. The whole area lies east and northeast of Globe and the Roosevelt Reservoir. The mining localities are all west of the western border of the San Carlos and Apache Indian reservations. The asbestos area within the reservation has not been prospected, although it is reported on good authority that asbestos occurs at several localities within them. Some asbestos of both high and low grade is reported as occurring on the new Winkelman road, 21 miles southeast of Globe, where five claims have been located by Antonio Brown, but no fiber has been marketed from this place. H. P. Wightman, of Globe, reports asbestos near Dudleyville, about 20 miles south of Globe, but more definite information is not available.

Arizona Asbestos Association, of Globe, Ariz.—This company (H. V. Snell, president; N. A. Nelson, superintendent) opened the mines on Ash Creek in 1914 and began a production which, except for a few months early in 1918, has continued ever since.

The area, including the numerous prospects of asbestos in the Ash Creek region, is about 2 miles long by two-thirds of a mile wide and embraces nearly 30 claims on the steep slopes on both sides of Ash Creek canyon. The horizontal sandstone and limestone strata, as well as the sheets or sills of igneous diabase, intruded into but mainly between the strata, crop out on the canyon slopes.

The asbestos is found in cross-fiber veins in the limestone only, but near its contact with the diabase, which is regarded as having caused the development of the serpentine and chrysotile by altering the limestone. The asbestos is mined by tunneling into the limestone along the asbestos. The Ash Creek mine has about 10,000 feet of underground workings arranged in four levels. The longest tunnel reaches a point about 600 feet into the mountain on the east.

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The miners save not only the crude fiber but also the rock that is sufficiently rich in mill fiber to justify milling at the mine.

The fiber ranges from a small fraction of an inch to several inches in length. All that is more than half an inch in length may be used for spinning and is included among the crude. The shorter fiber is mill fiber. The asbestos veins are generally arranged in groups in the limestone near its contact with diabase. A common form of occurrence in the Ash Creek mine has two groups of three to five small veins each, separated by serpentine and some limestone. The two groups where most fully developed have a combined thickness of about 4 feet and are separated by 4 feet of limestone which contains more or less nodular serpentine. Both groups of veins may be worked by one tunnel, and in rich portions of the mine asbestos may constitute 10 per cent of the rock removed. Some veins may be traced 100 feet or more with but few interruptions. In places, however, they wedge out, but they may come in again beyond at the same horizon if the limestone and diabase continue in the same relative position.

On Ash Creek the asbestos is developed generally in the basal portion of the limestone where it rests on diabase, but at several places it is developed in the upper portion of a limestone that is overlain by diabase.

In the Ash Creek mine asbestos has been mined for 600 feet into the mountain on the east. Beyond this point it continues eastward into the mountain, evidently for a considerable but unknown distance, which will depend on the continuity of the same relation between the limestone and the diabase. To prospect, develop, work, and drain most conveniently the portion of the mine farthest east from the entrance two tunnels have been run into the diabase; they are already in about 500 feet and are about 60 feet below the level of the limestone.

The outlet of the mine is on a steep slope, about 100 feet above the level of the creek. The slope affords an excellent dumping ground and mill site. Near the outlet of the mine a small mill, consisting of rock crusher, cyclone, and screens, prepares four grades of mill fiber for the market. The output of crude fiber is much greater than that of mill fiber, a feature that is of special economic interest inasmuch as the reverse situation exists in the asbestos mines of Canada and Russia.

About 140 men were employed at the mine in September, 1919. The mine is 41 miles from the nearest railroad shipping point, and truck roads are difficult to maintain. Asbestos not being a war mineral, embargoes on railroad shipment and labor difficulties incident to the war greatly reduced the production in 1918.

Penn Asbestos Mining & Refining Co.—This company began operations on about 20 claims a few miles north of the Ash Creek mine, on the upper part of Bald Head Creek. A limestone 50 feet in thickness rests on a thick sheet of diabase, and in the limestone near the contact a number of asbestos veins are exposed. They range in thickness from half an inch to a thin film. There is a considerable amount of milling rock but at the time of the writer's visit (Sept. 8, 1917) there was very little No. 1 crude in sight. Since then the underground workings have been greatly extended. A small production was reported in 1918 but in 1919 the mine was

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closed. The most promising fiber seen in the mines operated by the Penn Asbestos Mining Co. was on the Eagle claim north of 72 Spring, but the fiber was rather harsh. The Shanley group of claims and numerous others in the same region were not examined by the writer.

Colorado-Arizona Asbestos Mining Co.—A small production has been reported by this company on the Larson property, which lies on the steep slope 1,000 feet above Salt River, near the mouth of Cherry Creek. Three tunnels have been run into the basal portion of the limestone along the asbestos belt near the contact with the underlying diabase. At the time of the writer's visit (Sept. 8, 1917) there were three tunnels opened in somewhat broken and faulted limestone. The fiber looked best in the middle tunnel, a short distance from the opening. The 8-inch fiber belt had about 3 inches of good spinning fiber and appeared a promising prospect. However, as the mine was closed, the deeper underground workings could not be examined. East of the mine opening the continuity of the limestone is broken by faulting. The limestone is nearly 100 feet thick at this point and is overlain by a thick mass of sandstone, as at Ash Creek. The diabase appears to extend most of the way down to the river at Salt Lick. This property is said to be in litigation. It is being developed and operated under the direction of E. E. Miller.

American Ores & Asbestos Co.—This company was organized and its property developed by Charles F. Sloane, its first president. The company owns 28 claims near the head of Pocket Creek, about the summit of Coon Creek Butte, the southern portion of the Sierra Ancha, 8 miles northeast of the Roosevelt Reservoir. Its mine was opened in 1916 and actively operated in 1917 and 1918. Only crude fiber was shipped. No mill has yet been erected, but much mill rock has been accumulated in the process of mining. The asbestos occurs at two horizons in limestones separated by a thick sheet of diabase, and the upper limestone, about 30 feet in thickness, is overlain by a thin sheet of diabase. The upper zone is mined along a line of nearly a dozen openings for about a third of a mile. The lower zone, which is at the top of a limestone 150 feet thick, has thus far yielded only milling rock. In the mine in the Sierra Ancha the asbestos is along the contact of the diabase overlying the limestone but in the Ash Creek mines it is generally along the contact of diabase beneath the limestone. Mr. Sloane's interest in the mine has recently been sold to the Raybestos Co., of Bridgeport, Conn., which, with the United States Asbestos Co., of Lancaster, Pa., under the management of E. B. Shutts and H. E. Hacker, controls the mine. Men are at work (September, 1919) preparing to operate the mine and, if found advisable, erect a mill.

Roberts mine.—Reynolds Creek cuts a deep gash in the western slope of the Sierra Ancha, exposing the horizontal sandstone, limestone, and diabase that extend northward from the Pocket Creek region where the American Ores & Asbestos Co.'s mine is located. A Los Angeles company, managed by W. L. Roberts, began operations on Reynolds Creek, 2 miles above the road crossing the creek near some claims prospected in 1917 by B. L. Rogers, who sold about half a ton of fiber. The Denver Arizona Asbestos Mining Co. may operate its property in the same region.

Sloane mine.—Charles F. Sloane has recently acquired five claims from Clyde Kennedy on the eastern slope of the Sierra Ancha, locally

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known as Horse Mountain. The limestone is about 100 feet thick. The upper part is massive and the lower part thinner bedded. It is overlain, underlain, and intruded by diabase. There appear to be three belts of asbestos, 10 to 15 feet apart, in the upper portion of the limestone. Some of the asbestos is harsh, but most of it is of good spinning grade. Some fiber was shipped from this point in 1918 and arrangements are being made for further development and production. The locality is reached only by a rough trail over Horse Mountain, which is composed of sandstone forming prominent cliffs above the asbestos horizon.

The bed of asbestos-bearing limestone beneath the cliffs is nearly horizontal and extends north along the face of the Sierra Ancha and east into the upper valley of Cherry Creek, where it forms broad mesas between box canyons. Many asbestos claims have been prospected and located in the upper portion of Cherry Creek valley.

Alene Asbestos Association.—From the upper portion of the Cherry Creek region the asbestos-bearing limestone and associated rocks extend east into the drainage of Canyon Creek, where the mine of the Alene Asbestos Association is being operated on a small scale by Earle Pierce, who packs the output directly to Globe, a distance of nearly 50 miles.

There are eight claims around the edge of a limestone mesa that lies between two of the upper tributaries of Canyon Creek. Nearly a dozen tunnels have been run into the basal portion of the limestone, some of them 150 feet, just above its contact with diabase that underlies the mesa. Pierce's camp is on Sloane Creek, in the northwestern portion of the group of claims, where the exposures seem most promising. There are two belts of asbestos separated by about 4 feet of thin-bedded limestone. The upper asbestos belt has a maximum thickness of 10 inches and contains much good fiber; the lower belt, 3 inches thick, has 2 inches of fiber in places. In its richest parts the rock removed in making the tunnel contains about 10 per cent of asbestos, but generally the content is much less—1 to 3 per cent—and locally the asbestos disappears altogether. However, continuity of the serpentine or asbestos belt is the more frequent occurrence. When asbestos of good quality and in considerable quantity is in sight its removal is easily contracted for, but it is much more difficult to provide for the development work necessary to keep the mine going when the asbestos declines. For this reason the most successful asbestos mining of the region is managed by a strong company able to provide for the prospecting necessary as the mine advances. Experience has shown that although the quantity of asbestos is small, as compared with that of the Canadian mines, and the cost of mining is high, yet the superior quality of the fiber for insulating purposes should make it sufficiently valuable to justify the necessary expenditure for development.

Apache and San Carlos Indian reservations.—The Apache and San Carlos Indian reservations have recently been opened for mining metalliferous minerals, but not for mining asbestos. There is reason to believe that asbestos occurs in the reservations and in such quantity and quality as to render it especially valuable in commerce. No effort should be spared on the part of the Government to make this needed resource available in the reservations.

All the asbestos deposits of the Globe region described, except those of the Sierra Ancha, lie near the western border of the reservations.

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The rocks, however, are horizontal and extend east into the reservations. This is true of the mines of the Arizona Asbestos Association, the Penn Asbestos Mining & Refining Co., and the Alene Asbestos Association.

It is credibly reported that Antonio Brown, of Miami, Ariz., has asbestos claims on the Winkelman road, 21 miles southeast of Globe.

A deposit of asbestos within the San Carlos Reservation, northeast of Cassadaro Spring, is reported to be quite as promising as any other that has thus far been opened in Arizona.

An estimate of the relative importance of the Arizona asbestos field is indicated by the fact that in the last four years (1915–1918) it has produced about 1,900 tons of chrysotile, chiefly of spinning grade.

CALIFORNIA.

Notwithstanding the general decline in the domestic production of asbestos, the production in California in 1918 increased about 30 per cent over that of 1917 on account of the local demand. The principal producer was the Sierra Asbestos Co., of Nevada County. No production of crude fiber was reported, but four grades of mill fiber were prepared and used by the John D. Hoff Co., of Oakland, in making flooring, stucco work, steam-pipe covering, and asbestos cement.

A small production of asbestos was reported from Calaveras and Alameda counties. A company is said to have commenced operations on an asbestos property at the head of Los Gatos Creek, 25 miles northwest of Coalinga, in Fresno County, which shows fine crude fiber.

Prospects have been opened in Sierra, San Benito, Placer, Fresno, Napa, Shasta, and other counties of the State, but the fiber is too short for spinning and, for the most part, can not be worked profitably, although some crude occurs which is 1¼ inches long and, if in sufficient quantity, may be graded separately.

OREGON.

The Oregon Asbestos Mine Co., of Portland, Oreg., operated for a short time a mine a few miles north of Mount Vernon in Grant County. The output, which is reported small, contains three grades of material. The lowest grade was asbestic and occurred in the largest quantity.

WYOMING.

The asbestos deposits of Natrona and Fremont counties, Wyo., have already attracted much attention but have thus far yielded only a small quantity of commercial asbestos. In the report for 1917 attention was called to the deposit of the American Fireproofing & Mining Co., about 28 miles south of Lander. A small quantity of spinning fiber was obtained here and manufactured into yarn and wicking. The mine was practically closed in 1918, and the small production is reported to have been kept in storage unsold.

Recently a partial analysis of an asbestos sample collected by the writer at this mine in 1917 has been made by Roy L. Jones, of Pittsfield, Mass. The sample included the full length (about an inch) of the fibers, which extend completely across the vein. The ends of the fiber are somewhat darker than the middle portion, which

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is bright amber-colored. Mr. Jones reports [1]: "We clipped off the ends of the fiber. A separate analysis of the material removed showed 3.79 per cent of Fe_2O_3 although the fiber from which the ends were clipped contained only 1.27 per cent of Fe_2O_3." Mr. Jones states further: "Only ferric iron was present. We did not find any evidence of the iron in ore particles. It seemed to be chemically combined in the fiber."

GEORGIA.

In 1917 there were two companies mining and milling mass-fiber amphibole asbestos (anthophyllite), but owing to the demands of the war only one company, the Sall Mountain Co. of Georgia, continued its operations through 1918. It is, however, gratifying to note that its production remained about the same as in 1917. The best rock mined is that which is altered and partly softened by weathering. About 90 per cent of the rock mined appears in the finished asbestos product which is used largely in the manufacture of paints, fireproof cements, and other similar objects.

MARYLAND.

The restrictions on commerce resulting from the war cut off the supplies of amphibole asbestos from Italy used for chemical filters. The demand thus produced led to the discovery of a good supply of amphibole slip fiber in the weathered metamorphic rocks of Maryland. The unweathered fibrous rock is hard and brittle, but with weathering and disintegration it becomes more flexible, though retaining some textile strength. It can not be woven, but it so intermingles as to form a filter mat. It is mixed, washed, and treated chemically by the Powhatan Mining Co. so as to prepare it for Gooch filters. The quantity available for mining at any one place is generally small. The quantity of treated fiber sold is small and must bring high prices to attain financial success.

NORTH CAROLINA.

Sales from North Carolina were reported in 1918 for the first time in several years. The product was amphibole asbestos mined at Cane River, Yancey County, by W. C. Doak and N. C. McFalls.

IDAHO AND VIRGINIA.

A small quantity of amphibole asbestos was produced in Idaho and Virginia in 1917, but none was produced in 1918.

PRICES.

The strong demand for asbestos in 1918 caused a continued rise in prices for practically all grades of Canadian asbestos in the New York market, as quoted below by the Bennett Martin Asbestos & Chrome Mines (Ltd.), 220 Broadway, New York City.

Range of New York prices per short ton for Canadian chrysotile fiber, 1913–1918.

	1913	1914	1915	1916	1917	1918
No. 1 crude	$320–$350	$350–$375	$350–$400	$350–$1,250	$700–$1,500	$1,200–$2,000
No. 2 crude	200– 225	225– 250	225– 275	250– 900	500– 900	700– 1,200
No. 1 fiber	100– 125	100– 125	110– 150	150– 350	150– 450	400– 600
No. 2 fiber	75– 100	75– 100	80– 125	75– 150	75– 150	250– 300
Shorter fibers	10– 30	10– 30	10– 30	15– 60	18– 75	18– 125

[1] Letter dated August 2, 1919.

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Owing to the small production of the various grades of fiber in the United States there is no established price for them in the regular markets, but they are sold to consumers who, appreciating their value, are endeavoring by fair prices to encourage production and develop the domestic asbestos industry.

In Canada in 1918 the average price of crude fiber sold was $671.28 a short ton, an increase of $161 over the average sales price of crude in 1917. The average price in 1918 of the mill fiber was $46.88 a ton and of asbestic $2.03.

Owing to the fact that in practically all the Arizona fiber the harsh and the soft material are intermingled in such a way that it is difficult to separate them, these fibers do not bring as high prices as the Canadian. Soft Arizona fiber sells at $850 to $1,250 a ton, according to its length, and the harsh Arizona fiber at $350 to $600 a ton. The shorter fibers or mill rock have about the same value as the Canadian shorter fibers.

IMPORTS.

The United States is the world's largest manufacturer of objects made of asbestos. The greatest source of supply of raw asbestos is the Province of Quebec, Canada, from which it is imported into the United States free of duty. The total imports of unmanufactured asbestos in 1918 amounted to 137,700 short tons, an increase in quantity of about 2.7 per cent over the imports of 1917, but on account of the advance in price during the year the increase in the total value of imports of asbestos from Canada was about 50 per cent. Of the total quantity of asbestos imported in 1918 nearly 98 per cent came from Canada and the remaining 2 per cent came chiefly from South Africa. The imports from Canada constituted about 95 per cent of the total asbestos mined and sold in Canada in 1918.

Asbestos imported into the United States in 1917 and 1918.[a]

Country.	1917			1918		
	Unmanufactured.		Manufactured (value).	Unmanufactured.		Manufactured (value).
	Quantity. (short tons).	Value.		Quantity (short tons).	Value.	
British South Africa	1,791	$168,204	.....	837	$82,217	.....
Canada	131,525	4,148,217	$13,495	134,813	6,207,845	$10,208
Colombia	.....	.....	.....	1	1,138	.....
Cuba	.....	.....	.....	.....	.....	238
England	296	65,651	40,449	.....	.....	14,870
France	.....	.....	8,428	.....	.....	278
Ireland	.....	.....	.....	.....	.....	451
Italy	.....	.....	2,721	.....	.....	516
Japan	.....	.....	.....	.....	.....	80
Portuguese Africa	496	139,100	.....	2,049	46,385	.....
Scotland	.....	.....	3	.....	.....	835
	134,108	4,521,172	65,096	137,700	6,337,585	27,476

[a] Figures compiled from records of Bureau of Foreign and Domestic Commerce, U. S. Department of Commerce.

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EXPORTS.

The total exports of unmanufactured asbestos in 1918 amounted to 697 short tons, valued at $51,053, a decrease of approximately 1.6 per cent in quantity and of 56 per cent in value, as compared with 708 tons, valued at $116,580, in 1917. Unmanufactured asbestos was exported from the United States to Canada, Italy, England, and France, and the value per ton ranged from $13.41 to $189. Evidently the material was not crude but mill fiber. Manufactured asbestos was exported from the United States to 67 countries to the total value of $2,493,325, a figure which illustrates the large interest of the United States in manufacturing asbestos.

FOREIGN DEPOSITS AND PRODUCTION.

General statement.—The principal asbestos-producing countries, named in their order of importance, are Canada, South Africa, and Russia. Although nearness to market and abundance of supply of asbestos are most important factors in determining the sources of our imports, especially from Canada, it is chiefly the suitability of certain varieties of asbestos for special purposes that brings amphibole asbestos from Italy for chemical filters and the blue asbestos (crocidolite) from South Africa for electric welding and for spinning.

Canada.—Canada has furnished for many years the larger part of the world's supply of asbestos. The Canadian material is wholly chrysotile asbestos. The output has increased greatly during the last few years up to 1917, and prices have advanced even more rapidly than the output. In 1918, however, owing to delays incident to the war, the production of crude asbestos decreased. Asbestos is produced from cross-fiber veins in peridotite in the Province of Quebec at Black Lake, Thetford, Robertsonville, Coleraine, East Broughton, and Danville.

In 1918 the output in Canada included 4,313 short tons (3,913 metric tons) of crude asbestos, of which 3,692 short tons sold for $2,478,363, an average price of $671.28 a ton (3,349 metric tons at $740 a ton), and 139,143 short tons (126,231 metric tons) of mill stock, of which 137,770 short tons sold for $6,458,442, an average price of $46.88 a ton (124,985 metric tons at $51.67 a ton). There was also a production of 16,734 short tons of asbestic in 1918, which sold for $2.03 a ton (15,181 metric tons at $2.24 a ton). The total Canadian production of asbestos in 1918 was 141,462 short tons (128,334 metric tons), all chrysotile, of which more than 95 per cent was brought into the United States and sold for direct consumption or for manufacture into various objects.

Russia.—Russia has for many years ranked next to Canada in the production of asbestos from similar deposits, but has lately lost its rank to South Africa, where asbestos occurs in greater variety. The principal deposits in Russia occur on the eastern slope of the Ural Mountains, near Ekaterinburg. Other deposits occur in Siberia, at Irkutsk and Yenisei. The output of Russia increased from 8,010 short tons (7,267 metric) in 1905 to a maximum of 19,284 short tons (17,494 metric) in 1913; since then its production has declined somewhat. Imports to the United States ceased in 1915. The deposits are extensive, and under favoring conditions may yield a large output.

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South Africa.—South Africa excels all other countries in the variety of the asbestos it furnishes for the world's market from Rhodesia and the Union of South Africa. There are at least three varieties of asbestos of commercial importance in South Africa—chrysotile, crocidolite, and amosite. Chrysotile is a form of serpentine asbestos and the other two are forms of amphibole asbestos. Chrysotile occurs not only, as in Canada, in serpentine derived from the alteration of peridotite, but also, as in Arizona, in serpentine derived from the alteration of limestone. The countries containing important deposits of asbestos are Rhodesia, West Griqualand, and the Transvaal. Less important deposits occur in Natal.

Rhodesia produces white chrysotile asbestos of excellent quality, which compares favorably with the Canadian material. The output comes from two mines in Victoria and is shipped generally by way of Beira, in Portuguese South Africa. The output in 1913 was only 290 short tons, valued at about $78 a ton (263 metric tons at $86). In 1917, four years later, the output had increased to 9,562 short tons, valued at $91 a ton (8,675 metric tons, at $100 a ton). Owing to the war, however, production decreased about 10 per cent in 1918.

Crocidolite has long been known in the Asbestos Mountains of West Griqualand. It occurs in cross-fiber veins inclosed in a great succession of thinly bedded, dark-brown ferruginous shaly rocks, and the continuous fibers of crocidolite are generally not less than 2 to 6 inches in length.[1] The better quality occurs in hard rock. It is remarkable not only on account of its blue color but also for its high content of peroxide of iron. The merits of crocidolite have been slowly recognized, but it is now in general use for many purposes.

The output during the year 1898 is said to have averaged about 100 tons a month. Kafir labor is employed. About 25 per cent of the fiber is an inch or more in length. The Cape Asbestos Co. is the chief producer and consumer of blue asbestos at its factories in England, Germany, Italy, and elsewhere. The business of the Cape Asbestos Co. expanded so much in 1918 that its plant at Basking, England, had to be enlarged.

The mode of occurrence and distribution of asbestos in the Union of South Africa, especially in the Transvaal, have been well described recently by A. L. Hall.[2] Three varieties of asbestos occur there—chrysotile, crocidolite, and amosite. The white to pale-green chrysotile is remarkable in being like that of Arizona in its association. It occurs in altered dolomite near the upper contact of a diabasic sill in the Carolina district. The length of the fiber ranges from 6½ inches downward and is usually from one-half to three-fourths of an inch. The quantity available is said to be limited—only one mine furnished a steady output in 1917—and about half is said to be spinnable. A chemical analysis of the Carolina chrysotile shows that it contains no iron, whereas that of Canada has 2.53 per cent of iron oxides.

The lavender-blue crocidolite is reported as occurring in large quantities as cross-fiber veins parallel to the bedding in banded ironstone a little above the base of the Pretoria series. The greatest length of the fiber is several inches, and the proportion of available fiber is uncertain.

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[1] Cirkel, Fritz, Chrysotile asbestos, its occurrence, exploitation, milling, and uses, 2d ed., p. 239, 1910.
[2] Hall, A. L., Union of South Africa Dept. of Mines and Industries Geol. Survey Memoir No. 12, and also in the South Africa Geol. Soc. Trans., vol. 21, 1918.

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A third variety of asbestos, designated as amosite, is a grayish-white monoclinic iron amphibole, which at the present time forms the bulk of the output of asbestos in the Lydenburg and Pietersburg districts; and it is reported by the Department of Mines[1] that recent discoveries in the Transvaal indicate a source from which an enormous supply of asbestos will soon be obtainable.

The total production of the Union of South Africa in 1918 was 3,674 short tons (3,333 metric), which, with 8,574 short tons (7,778 metric) produced by Rhodesia, makes a total of 12,248 short tons (11,111 metric) output for South Africa in 1918. In 1917 the total output was 15,782 short tons (14,317 metric), mainly crude fiber, much of which rivaled the Canadian.

Other countries.—In addition to the deposits of asbestos already noted, considerable deposits of asbestos have been reported and to some extent operated in Australia, Italy, Mongolia, New Zealand, Tasmania, the Philippine Islands, Cyprus, India, and Japan, but in general these countries afford but a small part of the asbestos of the world.

Mr. H. V. Snell, of Globe, Ariz., recently presented an extraordinary sample of pale-blue crocidolite from a new locality in South America. It is a remarkably long, soft, and fine silky fiber with high tensile strength. It has been examined by W. T. Schaller in the chemical laboratory of the United States Geological Survey and found to contain much iron and soda which, with its physical properties, show it to be crocidolite. The fibers are uniformly fine silky throughout a length of nearly 10 inches. They end abruptly as if cut off, but the terminations may be the sides or walls of a 10-inch cross-fiber vein. Similar large veins occur in South Africa. If South American crocidolite like the sample received occurs in such quantity as to be of commercial interest it will quickly attract the attention of asbestos producers and become a factor in the asbestos industry of America. Of course, such long fiber would have to be cut into about 3-inch lengths before it could be readily worked by the machines now in use.

WORLD'S PRODUCTION.

World's production of asbestos, 1913–1918, in metric tons.

Country.	1913	1914	1915	1916	1917	1918	Percentage of total in 1918.
Canada: [a]							
Crude	(5,135)	(3,763)	(4,872)	(5,340)	(4,883)	(3,349)	.....
All grades	124,239	87,580	100,826	121,053	122,925	128,334	88—
South Africa:							
Rhodesia [b]	263	442	1,823	5,586	8,675	7,778	5+
Union [c]	873	1,080	1,940	4,224	5,642	3,333	2+
Russia [d]	17,494	15,691	[e] 9,779	[e] 8,192	.....	[e] 6,000	4+
United States	998	1,131	1,570	1,342	1,527	909	1—
Italy [f]	175	171	162	82	85	[e] 80	.....
	144,042	106,095	116,100	140,479	138,854	146,434	100

[a] Reports of mineral production of Canada, Canada Dept. Mines, Mines Branch.
[b] Rept. secretary mines, Southern Rhodesia, for the years 1913–1918.
[c] Union of South Africa Ann. Repts. secretary mines and industries and mining engineers for 1918, p. 28.
[d] Mineral industry, 1918.
[e] Estimated; statistics not available.
[f] Rivista del Servizio minerario, 1917, p. 63.

[1] Union of South Africa Ann. Repts. secretary mines and industries and mining engineers for 1918, p. 114.

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TALC AND SOAPSTONE.

By J. S. Diller.

TALC.

PRODUCTION.

Talc is not a war mineral, but it was used for some definite war purposes and its production has increased somewhat over pre-war years.

The total sales of domestic talc in 1918 amounted to 191,477 short tons, valued at $2,089,960; those of 1917 amounted to 198,613 short tons, valued at $1,889,672. Therefore 7,136 short tons, or nearly 4 per cent, less domestic talc was sold in 1918 than in 1917, but because of the advance in price the value was $200,288, or about 11 per cent, greater.

Thirty-six producers of talc reported to the United States Geological Survey in 1918, of whom there were 8 in California, 6 in Vermont, 6 in North Carolina, 5 in Virginia, 3 in New York, 2 each in Georgia, Maryland, and Pennsylvania, and 1 each in Massachusetts and New Jersey.

Vermont ranked first in production, with a decreased output, the total sales being 90,537 short tons, valued at $775,012. New York, with a decreased output, ranked second in quantity and first in value, the total sales being 71,167 tons, valued at $902,100. California ranked third, with a total production of talc and soapstone of 11,864 tons in 1918. This was more than 2½ times the quantity of talc produced by California in 1917, besides a considerable quantity of soapstone. This decided advance in the production and utilization of talc, notwithstanding a slightly local decline in the average price on the Pacific coast, is one of the most important and significant features of the year in the development of the domestic talc industry.

Talc mined and sold in the United States in 1917 and 1918, by States.

State.	1917		1918		
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Average price per ton.
California	4,152	$74,000	10,364	$170,775	$16.48
New York	74,671	881,462	71,167	902,100	12.68
North Carolina	2,175	41,766	1,661	72,348	43.56
Vermont	93,960	625,150	90,537	775,012	8.56
Virginia	6,432	85,856	3,265	24,723	7.57
Georgia [a], Maryland, Massachusetts, New Jersey, Pennsylvania	17,223	181,438	14,483	145,002	10.01
	198,613	1,889,672	191,477	2,089,960	10.91

[a] The order of output of this group in 1918 is as follows: Pennsylvania, Maryland, Massachusetts, Georgia, New Jersey.

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Talc mined and sold in the United States in 1917 and 1918, by classes.

Condition in which marketed.	1917		1918		
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Average price per ton.
Rough (crude)	12,369	$68,440	13,263	$106,228	$8.01
Manufactured into pencils and blanks [a]	5,781	176,404	945	114,002	120.64
Ground [b]	180,563	1,644,828	177,269	1,869,730	10.55
	198,613	1,889,672	191,477	2,089,960	10.91

[a] Includes slate pencils and metal workers' crayons and blanks used in making acetylene burners and other objects.

[b] For foundry facings, filler for paper, paint and rubber goods, toilet powder, foot ease, lubricators for dressing skins and leather, etc.

OCCURRENCE AND DISTRIBUTION.

Talc is an acid metasilicate of magnesium whose softness, greasy feel, and resistance to the action of heat and acid render it useful for many purposes. Another mineral, pyrophyllite, a hydrous silicate of alumina, resembles talc in some of its properties and is useful for the same purposes. It is mined and sold as talc at Glendon, Moore County, N. C.

Talc occurs in highly crystalline rocks, schists and gneisses, and generally results from the alteration of other magnesian minerals, such as pyroxene and hornblende. Its occurrence in commercial quantities is limited to ancient crystalline terranes. The finer qualities of talc are commonly associated with limestone and have been derived, as in New York and western North Carolina, from the alteration of tremolite schist in the limestone. The lenses of talc or tremolite schist usually stand on edge in the limestone and have to be mined by underground methods.

In North Carolina and Georgia the talc is associated with limestone, but in Harford County, Md., where the largest producing mine of fairly high grade talc is now in operation, the talc or soapstone, as it is often called, is an alteration product apparently of pyroxene in a large dike of basic igneous rock, probably pyroxenite or peridotite. Much of the rock is changed to serpentine [1] and finally to talc.

Of the great bulk of domestic talc marketed in the United States 95 per cent comes from nine States in the mountainous belt near the Atlantic coast, and about 5 per cent comes from California in the mountainous belt near the Pacific coast. In the broad stretch of 2,000 miles across the Mississippi Valley and the Great Basin there are at present no producing talc mines, although talc is known to occur and mines may yet be opened in the Rocky Mountains

PRINCIPAL USES.

The principal uses of powdered domestic talc are in the manufacture of paper and toilet powder, but the most valuable talc is that which is so uniformly fine grained that it can be readily cut and

[1] According to the Maryland Geological Survey's report on Cecil County, the large dike of serpentine that crosses Cecil County and Susquehanna River at Bald Friar enters Harford County and a mile west of Dublin contains the talc mined by the Harford County Talc Co.

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bored in making gas tips and similar objects. The United States is well supplied with low and middle grades of talc suitable for paper but is deficient in high-grade material for toilet powder, pencils, and gas (lava) tips. Most of the domestic material of high grade comes from North Carolina and Georgia, but recently it has been mined also in California, Vermont, and Maryland.

IMPORTS.

About 4,440 tons, or 24 per cent, less talc was imported for consumption in 1918 than in 1917 and prices advanced everywhere. About 10 per cent of the imported talc was crude and the remainder ground. Of the imported talc 96 per cent came from Ontario, Canada. The remainder was chiefly high-grade material from Italy, but a small portion came from France.

Talc imported for consumption[a] in the United States in 1917 and 1918.[b]

Kind.	1917		1918		
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Average price per ton.
Crude and unground steatite and French chalk[c]	2,452	$10,710	1,434	$9,253	$6.45
Ground talc, or steatite, cut, powdered, washed, or pulverized[d]	16,157	258,787	12,735	251,323	19.73
	18,609	269,497	14,169	260,576	18.39

[a] General imports and imports for consumption for any period will differ to the extent that the value of entries for warehouse for the period differs from the value of withdrawals from warehouse for consumption. The term "entry for consumption" is the technical name of the import entry made at the customhouse and implies that the goods have been delivered into the custody of the importer and that the duties have been paid on the dutiable portion. Some of them may be afterwards exported.
[b] Statistics compiled from records of the Bureau of Foreign and Domestic Commerce, Department of Commerce.
[c] Duty free.
[d] Duty of 15 per cent ad valorem.

General imports of talc, ground or manufactured, into the United States, 1917 and 1918.[a]

Country.	1917		1918		
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Average price per ton.
Canada	10,287	$145,404	12,185	$214,036	$17.57
England	55	869			
France	1,512	11,024	22	491	22.32
French Africa	33	678			
Italy	4,167	98,064	490	36,575	74.64
Jamaica	66	1,220			
Japan	10	184			
Spain	1	11			
	16,131	257,454	12,697	251,102	19.78

[a] Statistics compiled from records of the Bureau of Foreign and Domestic Commerce, Department of Commerce.

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TARIFF.

According to the present tariff, crude and unground talc enters free of duty, but on French chalk, ground, cut, powdered, washed, or pulverized talc, there is a duty of 15 per cent ad valorem.

A bill (H. R. 9063) was introduced September 5, 1919, by the chairman of the Ways and Means Committee of the House of Representatives, to increase the present duty on talc as follows: Talc, steatite, soapstone, and French chalk, crude and unground, ½ cent per pound; when ground, washed, pulverized, or powdered, 1 cent per pound; when cut or sawed or in the form of blanks, crayons, or cubes, 2 cents per pound; and 50 per cent ad valorem on manufactures of talc, talcum, steatite, soapstone, and French chalk wholly or partly manufactured if not decorated; if decorated, 60 per cent ad valorem. An association of producers of talc and soapstone has recently been formed (August, 1919) in the United States (Freeland Jewett, of Boston, president, and R. B. Ladoo, of the Bureau of Mines, Washington, D. C., secretary) and one of its principal activities for the present will be the consideration of protective tariff measures.

WORLD'S PRODUCTION.

United States.—The world's production of talc for the last six years 1913–1918, inclusive, is shown concisely in the accompanying table. Of the total production probably less than 1 per cent was used in crude form and the remainder was ground. The large output of the United States (58 per cent of the world's production in 1918) is a matter of interest, but when we consider that in addition to its large production the United States imported more than 10 per cent of the total quantity of talc produced by all other countries combined and exported very little, it becomes strikingly evident that the United States is preeminently a consumer of talc. Of the world's production in 1918 the United States produced 58 per cent and consumed nearly 63 per cent, leaving approximately 37 per cent for consumption by the rest of the world.

France.—France ranks next to the United States in the production of talc, and the French talc is of excellent grade. The department of Ariège, near the north foot of the Pyrenees, furnishes more than four-fifths of the total output of France. The French chalk so widely known comes from southeastern France near Toulon, a port on the Mediterranean. The production of talc in France in 1913 was more than 66,000 short tons (60,175 metric tons). As the war advanced production and exportation decreased greatly. However, the resources and possible production have remained unimpaired, and there will be an output, apparently, of more than 60,000 tons annually when production has been fully resumed.

Italy.—The talc of Italy is highly prized for its purity and is imported chiefly for use in the manufacture of toilet powder, though some of it is so compact that it can be cut and used for gas tips. The principal region of production is in the Alps of northwestern Italy, west and southwest of Turin. Italy furnished about 8 per cent of the talc produced in 1918, and nearly 2 per cent of its output came to the United States.

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Canada.—The only important center of production of talc in Canada is in Ontario, Hastings County, near Madoc, about 100 miles northeast of Toronto. Of the 18,190 short tons (16,502 metric tons) produced in 1918, having an average value of $6.20 per short ton, 67 per cent was imported into the United States at an average declared value of $17.57 per ton. Much of the talc was imported crude and ground in the United States, but a large part of it was ground in Canada. Much of it is used for paper, but it lacks the fibrous quality of the New York talc, though it is generally freer from grit.

Austria.—Statistics of the production of talc in Austria are not available for the years mentioned in the table, but the United States Department of Commerce reports exports of talc from Austria-Hungary in 1913 amounting to about 8,083 metric tons. If we assume that about half of the total output of talc in Austria is used in that country and the other half exported the total production in 1913 would have been about 16,000 metric tons. On account of the disturbed condition of the country the production in 1914 and later years fell off to not more than 12,000 metric tons. The chief producing center is in Styria, about 100 miles southwest of Vienna. Much talc is used in Austria in the manufacture of paper.

Norway.—The Province of Bergenlius, northeast of Bergen, Norway, produced about 12,000 metric tons of talc during the four years 1913–1916, inclusive, an average of about 3,000 tons annually.

Spain.—Spain has long been a moderate but variable producer of talc. Its chief source is on the southern slope of the Pyrenees, in the Province of Gerona, northeast of Barcelona. The average production for the last six years has been 3,386 metric tons, which agrees closely with the output in 1918 and shows that the industry has not been much influenced by the war.

Germany.—The talc of Germany comes chiefly from the Fichtel Gebirge in Bavaria, where the average production for seven years prior to the war was about 3,000 metric tons. Recent statistics are not available, but 3,000 tons may be assumed as a rather generous estimate of the output under the disturbed conditions of 1918.

India.—One of the most widely distributed minerals in India, according to the Geological survey of India, is steatite, either in the form of coarse potstone (soapstone), so called on account of its general use in making pots and dishes, or in the more compact form suitable for cutting. The production has greatly increased in the last few years, especially at Jubbulpore, in the central provinces, and at Meiktila, in Burma. The material imported into the United States from India is largely of the grade suitable for lava tips and similar objects and reaches this country chiefly through England.

British South Africa.—British South Africa is beginning to attract the general attention of talc users on account of the quality, variety, and abundance of talc which it contains, especially in the Transvaal and Rhodesia. Important production began in 1916, and the deposits promise to furnish another source for the higher grades of talc.

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World's production of talc, 1913–1918.

[In metric tons of 2,204.6 pounds.]

Country.	1913	1914	1915	1916	1917	1918	Percentage in 1918.
United States	135,417	137,066	150,898	175,368	180,180	173,706	59
France [a]	60,175	(a)	(a)	(a)	(a)	57,568	19
Italy [b]	24,001	22,477	28,931	27,483	21,863	[b] 23,951	8
Canada [c]	11,113	9,804	10,782	11,888	14,336	16,502	6
Austria [d]	[d] 16,000	[d] 15,000	[d] 12,000	[d] 12,000	[d] 12,000	[d] 12,000	4
Norway [e]	1,500	2,100	2,990	5,500	.....	3,023	1
Spain [f]	4,407	4,612	963	3,556	3,450	3,328	1
Germany [g]	.....	.....	.....	.....	.....	3,000	1
India [h]	2,565	1,015	1,094	1,233	7,964	[h] 2,772	1
British South Africa [i]	.....	.....	.....	120	712	608	.....
						296,478	100

[a] Statistique de l'industrie minérale en France pour l'année 1913, p. 61. (Statistics from 1914 to 1917 not available. Average production for 1912 and 1913 given under 1918.)
[b] Rivista del Servizio minerario, 1917, p. 63. Not available for 1918, but the average crude for 1913–1917 is 23,951 tons.
[c] Canada Dept. Mines, Mines Branch, Ann. Repts., 1913–1918.
[d] Statistics for Austria not available for years mentioned in table. Department of Commerce reports talc exported from Austria-Hungary in 1913 as 80,828 metric quintals, or 8,083 metric tons. Much talc is used in Austria, especially for paper. If we assume that somewhat less than half of the total output is used in Austria, the total production in 1913 was about 16,000 tons. As talc is rather a peace mineral and war delayed production, the output in 1915–1918, inclusive, would probably average less than 12,000 metric tons annually, although the capacity of the mines apparently is greater.
[e] Norges Officielle Statistik—Norges Bergverkskrift.
[f] Estadistica minera de España, 1913–1918.
[g] Mineral Industry, 1918.
[h] India Geol. Survey Rec., vols. 46–49. Statistics not available for 1918. Average for 1913–1917 is 2,772 metric tons.
[i] Ann. Repts. Government Mining Engineer, Union of South Africa, Dept. Mines, 1917.

SOAPSTONE.

PRODUCTION.

The name soapstone is correctly applied in the United States to a massive crystalline rock composed chiefly but not wholly of talc. The interlocking grains of talc and associated mineral matter bind the mass together. As talc is a soft mineral and easily broken, soapstone is a weak rock, and the loss by breakage in quarrying it, sawing it into slabs, making it into various objects, and transporting them to market is very great, roughly estimated at 90 per cent of the total quantity quarried.

Soapstone is usually quarried in large blocks, then sawed into slabs, and for the greater part manufactured into various objects in mills near the quarries before being marketed. The selling price ranged in 1918 from $10 to $40 a ton, and the average was about $35 a ton.

Virginia, with three large quarries, is by far the largest producer and manufacture of soapstone. California and Vermont have one producing plant each and together yield nearly one-tenth as much as Virginia. The total production of soapstone in the United States in 1918 was 16,830 short tons, valued at $591,059. No imports or exports of soapstone into or from the United States are reported.

OCCURRENCE.

The rock from which the soapstone in Virginia is obtained forms a large belt in an intrusive mass extending northeastward through Nelson, Albemarle, and Orange counties. This large intrusive mass

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will afford an abundant supply for many years to come. It appears to have been derived from what was originally a basic igneous rock, probably pyroxenite or peridotite. The pyroxene and olivine in many places are altered to serpentine, and the alteration may finally result in the formation of talc. The hardest soapstone is only partly changed to talc and contains much residual pyroxene. It takes a dull polish which makes it more attractive for some purposes. In Maryland where similar rocks occur they are in places completely altered to talc so compact, fine grained, soft, and free from impurities that it can be readily carved, and in such places the rock should be called talc instead of soapstone.

WORLD'S PRODUCTION.

Soapstone is one of the rocks that was most widely useful to primitive man, who, on account of its softness, resistance to sudden changes of heat, and slow radiation, employed it chiefly for making pots; and it thus became generally known as potstone. Similar uses still exist in the soapstone stove, foot-warmer, and fireless cooker, although the principal application of soapstone, especially in this country, is in laundry tubs and laboratory tables, hoods, and tanks.

World's production of soapstone (as far as available), 1913–1918, in metric tons.

Country.	1913	1914	1915	1916	1917	1918
United States	24,097	19,240	18,647	17,828	18,357	15,268
United Kingdom	40	180	850	301	1,233	936

The commercial production of soapstone in the United Kingdom began about 1912 and is increasing. Part of the output comes from Scotland, but most of it from Ireland. France, Spain, and Germany are each represented as producing soapstone or steatite, but the product is reported with talc, and the proportion of each can not be readily ascertained.

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CEMENT.

By Ernest F. Burchard.[1]

INTRODUCTION.

The marked decline in the output of cement in 1918, amounting to about 22 per cent, as compared with 1917, was the result of the continued curtailment begun in 1917 of building operations not essential to the war and of the continuation of the war restrictions imposed by the Government upon fuel supplies, transportation facilities, and labor. The output in 1918 was the lowest since 1909. On the other hand, wages and fuel costs continued to increase to such an extent that selling prices of cement were advanced greatly, that of Portland cement reaching an average of nearly $1.60 a barrel at the mills, the highest price in 20 years.

Statistics of the cement industry in 1918 were issued on January 21, 1919, by the United States Geological Survey in a press bulletin which gave estimates of shipments, prices, production, and stocks; and an advance statement of final figures of shipments, prices, production, stocks, exports, and imports was issued, also as a press bulletin, May 19, 1919, and was published in the "Preliminary report on the mineral resources of the United States," August 7, 1919, pages 32 and 33. The estimates of shipments exceeded the final figures by 1 per cent, those of production by 0.7 per cent, and those of stocks by 1.3 per cent.

This chapter includes a section on concrete ships in 1918, prepared by R. W. Lesley, of Philadelphia, Pa., associate member of the American Society of Civil Engineers, one of the pioneer manufacturers of Portland cement, and a member of the committee on concrete ships of the American Concrete Institute, in continuation of an article by him on the same subject in this chapter for 1917, and also a section on imports and exports of cement in foreign countries, furnished by R. S. Schultz, jr., recently works manager of the Marquette Cement Manufacturing Co., La Salle, Ill. These papers deal with subjects that are of present interest to the cement industry and to the public, and the writer desires to express herewith to the authors his appreciation of their courtesies.

THE CEMENT INDUSTRY IN RELATION TO THE WAR.

The course of cement manufacture during the last five years affords an illustration of the way in which an industry of vital importance to the Nation in war time can do its share and yet suffer depression as the result of conditions imposed by the war.

[1] The statistics of production of domestic cement were prepared by Mrs. H. L. Bennit, those showing imports into and exports from the United States were compiled by J. A. Dorsey, and those pertaining to foreign countries by R. S. Schultz, jr.

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In an earlier bulletin[1] it was pointed out that the cement industry in the United States enjoys absolute independence of foreign supplies of raw materials or manufacturing machinery and that the United States produces more Portland cement than is consumed within the country. The raw materials are abundant and cheap, and manufacturing plants are well distributed throughout areas of notable consumption.

The military importance of cement can not be overestimated. It is used mostly as an ingredient in concrete, and concrete possesses great adaptability to a wide variety of uses. Besides being cheap, easily and quickly handled, sanitary, and durable, concrete is suitable for structures that are submerged as well as those in dry places, and all these characteristics taken together render it of great military importance. Among the military structures in which concrete is used are armories, barracks, roads, bridges, coast and interior fortifications, gun emplacements, trench linings, bombproof shelters, magazines for explosives, tunnels, retaining walls, sea walls, wharves, dry docks, water reservoirs, aqueducts, sewers, sewage-treatment works, incinerators, stables, floors, roofs, munition-factory buildings, warehouses, fuel-oil tanks, barges, ships, and structures in the interior of battleships.

CONDITIONS DURING THE WAR.

The year 1914 witnessed the first recorded decrease in annual production of Portland cement in the United States. The industry had experienced a remarkable growth during the preceding 10 years, and it was only natural that a slight check should come at this time. The average price per barrel in bulk at mills in 1914, 92.7 cents, represented a decrease of 7.8 cents from the average of 1913, and indeed the beginning of the war in Europe may be said to have marked a depression in the American cement industry from which only a temporary recovery was made during the whole period of the war.

The Portland cement industry showed no noteworthy development in 1915, notwithstanding the greater activity in the metal industries. In view of the experiences of 1914 manufacturers exercised considerable caution, the result of which was a slight increase in the volume of shipments, a small decrease in the quantity of cement manufactured, and a considerable decrease in the stocks of cement on hand, all indicating a correction of the tendency toward overproduction that had manifested itself at times during the preceding few years. The average price in 1915, 86 cents a barrel, represented a decrease of 6.7 cents a barrel below the price in 1914, and the estimated consumption of Portland cement per capita in the United States was 0.83 barrel, compared with 0.77 barrel in 1914. The total production in 1915 represented about 66 per cent of the apparent actual manufacturing capacity, according to figures reported to the Geological Survey.

In 1916 the conditions were more satisfactory. At the beginning of the year the industry was already feeling the effects of the gradual revival of activity in construction work, and throughout the year mills in all parts of the United States were busy manufacturing and shipping cement at a rate greater than at any other time since 1913, although labor troubles and lack of freight cars operated as a handicap.

[1] Burchard, E. F., Our mineral supplies—Portland cement: U. S. Geol. Survey Bull. 666-S, 1917.

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Higher prices prevailed, averaging $1.103 a barrel at the mills, and six new plants reported their first production in 1916, one each in California, Minnesota, New York, Oklahoma, Oregon, and Texas. The plants in Oregon and Texas are close to tidewater. About 68 per cent of the cement-manufacturing capacity was employed during 1916.

As a result of increased business in 1916 stocks of Portland cement were reduced below the normal, yet the reserve of more than 8,250,000 barrels on hand at the beginning of 1917 proved to be sufficient for emergencies. The consumption of Portland cement per capita in 1916 was estimated at 0.89 barrel, the highest during the period of the war.

In 1917 the cement industry, in common with most other manufacturing industries, faced unusual conditions. The demand for cement was generally very good during the first five to eight months but showed a decided falling off during the remainder of the year. The strong demand in the early part of the year so greatly stimulated production that the quantity of finished cement of all kinds manufactured reached a total of more than 93,000,000 barrels—the largest production ever recorded, and yet only about 68 per cent of the manufacturing capacity was reported to have been employed. The total shipments, on the other hand, decreased, and the stocks increased accordingly. The consumption per capita in 1917 was estimated at 0.84 barrel. The average price of cement ($1.354) represented an increase of 25 cents over the average for 1916, and, although the net profits appear not to have been great, the effect of prices high enough to minimize the chances of loss and the absence of price cutting seem both to have stimulated production and to have encouraged the completion of three new mills and the resumption of operations at one mill that was idle in 1916.

The only step taken by the Government to insure an adequate supply of cement for military purposes and at the same time hold prices at fair figures was taken in cooperation with representatives of the cement industry in 1917, shortly after the entrance of the United States into the war, when the first scale of prices shown on page 581 was fixed. It was furthermore agreed that the Government requirements should be distributed as evenly as possible among the cement mills tributary to the localities where the cement was needed.

The adverse effects on the cement industry of the entrance of the United States into the European war began to be generally felt after the middle of the year and consisted mainly in shortage of fuel, railroad cars, and labor, and in the lessened demand for cement in some districts resulting from the curtailment of building operations not essential to the war. The necessary railroad embargoes were far-reaching; they affected supplies of fuel and other raw materials and of machinery and mill supplies and also shipments of cement to so great an extent that some mills had to be closed temporarily on account of lack of storage capacity.

In 1918, as has already been stated, the production of cement was the lowest since 1909. The average per capita consumption was 0.64 barrel in 1918 and the manufacturing capacity utilized was about 51 per cent of the total. The military requirements of the

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Government, amounting to about 11,000,000 barrels, were easily met by the producers, the commercial business was subnormal on account of curtailment in construction work, and exports suffered through lack of ships. The average price per barrel ($1.596) represented nearly as large an increase as in 1917 and was the highest price realized in the last 20 years.

If the five years of the war are considered as a whole the average annual production and shipments of Portland cement each amounted to nearly 86,000,000 barrels—a quantity greater than the annual production of any year prior to 1913, but as compared with the average annual capacity of the mills for manufacturing cement during this period, which is conservatively estimated at about 130,000,000 barrels, it is seen that the cement industry was abnormally restrained. The lowest factory prices during the war were about 14 per cent less than the pre-war price of 1913, and the highest prices were nearly 59 per cent above the level of 1913. Wholesale market prices dropped correspondingly, but they also rose to greater excesses above the price of 1913, in some places recording advances of more than 110 per cent.

PRODUCTION OF HYDRAULIC CEMENTS.

The total quantity of Portland, natural, and puzzolan cements marketed or shipped from the mills in the United States in 1918 was 71,348,474 barrels, valued at $113,554,854, as compared with 91,342,930 barrels, valued at $123,210,458, in 1917—a decrease in quantity of 19,994,456 barrels, or 21.9 per cent, and a decrease in value of $9,655,604, or about 7.8 per cent.

Principal hydraulic cements shipped from factories in the United States in 1916, 1917, and 1918.

Class.	1916		1917		1918	
	Quantity (barrels).	Value.	Quantity (barrels).	Value.	Quantity (barrels).	Value.
Portland	94,552,296	$104,258,216	90,703,474	$122,775,088	70,915,508	$113,153,513
Natural	842,137	430,874	639,456	435,370	432,966	401,341
Puzzolan						
	95,394,433	104,689,090	91,342,930	123,210,458	71,348,474	113,554,854

The historical table that follows gives the production and value of natural, Portland, and puzzolan cements so far as recorded by the Geological Survey. The curves in figure 66 show graphically some of these data from 1890 to 1918. The figures in the table represent actual production of Portland cement for all years and of natural and puzzolan cements until 1911, inclusive, after which the figures for these cements represent shipments. In 1916, 1917, and 1918 there was but one manufacturer of puzzolan cement; hence the shipments of puzzolan are included with those of natural cement. No figures for production or stocks are collected for natural and puzzolan cements because production and shipments are generally nearly the same and stocks are relatively small.

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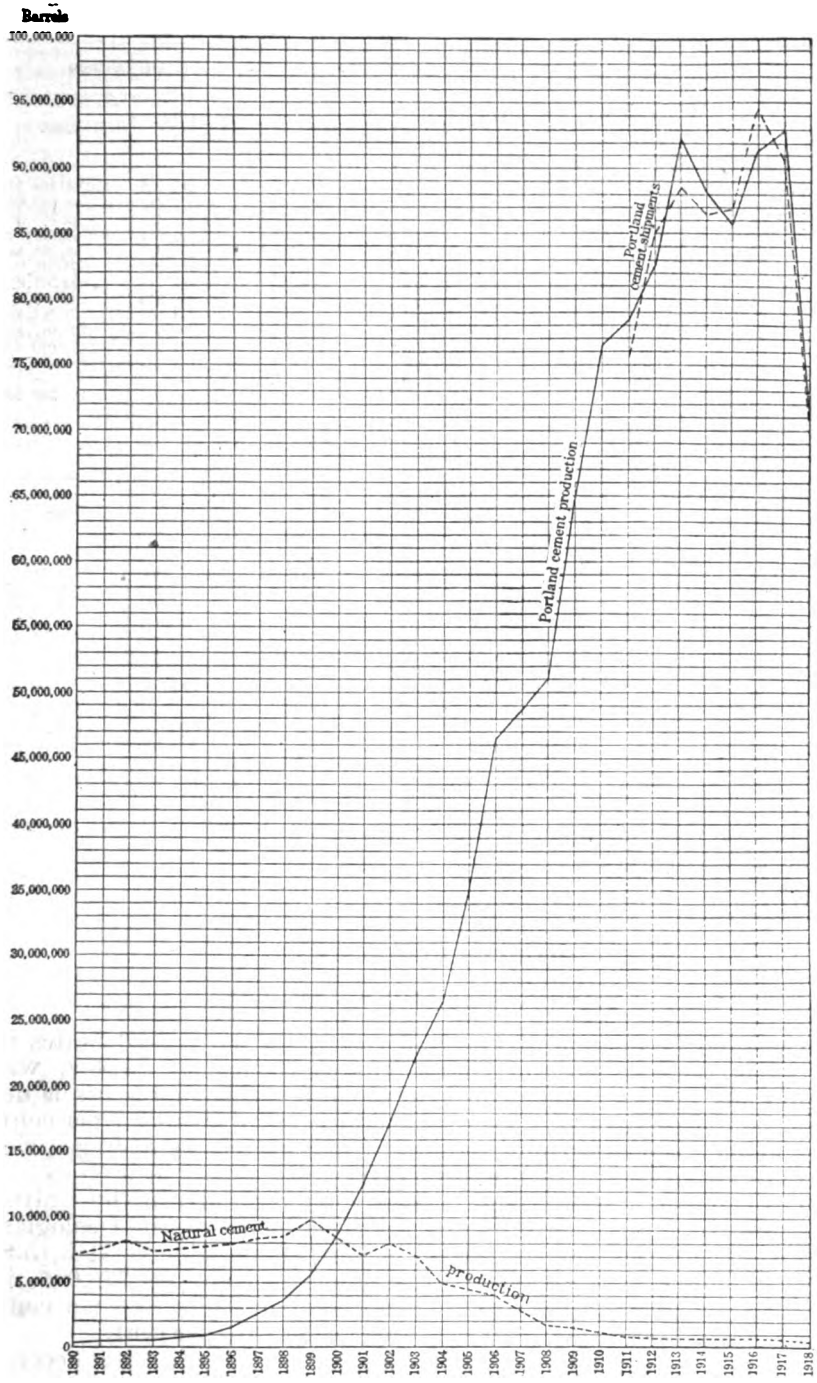

FIGURE 66.—Production of Portland and natural cements, 1890–1918, and shipments of Portland cement, 1911–1918.

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Principal hydraulic cements produced in the United States, 1818–1918.[a]

Year.	Natural cement.		Portland cement.	
	Quantity (barrels).	Value.	Quantity (barrels).	Value.
1818–1907	225,965,550	$145,407,732	[b] 236,610,203	[b] $264,364,571
1908	1,686,862	834,509	51,072,612	43,547,679
1909	1,537,638	652,756	64,991,431	52,858,354
1910	1,139,239	483,006	76,549,951	68,205,800
1911	926,091	378,533	78,528,637	66,248,817
1912	821,231	367,222	82,438,096	67,016,928
1913	744,658	345,889	92,097,131	92,557,617
1914	751,285	351,370	88,230,170	81,789,368
1915	750,863	358,627	85,914,907	73,896,820
1916	[c] 842,137	[c] 430,874	91,521,198	100,947,881
1917	[c] 639,456	[c] 435,370	92,814,202	125,670,430
1918	[c] 432,966	[c] 401,341	71,081,663	113,446,334
	236,237,976	150,447,229	1,111,850,201	1,150,540,599

Year.	Puzzolan cement.		Total.	
	Quantity (barrels).	Value.	Quantity. (barrels).	Value.
1818–1907	[d] 3,995,313	[d] $3,323,517	466,571,066	$413,095,820
1908	151,451	95,468	52,910,925	44,477,656
1909	160,646	99,453	66,689,715	53,610,563
1910	95,951	63,286	77,785,141	68,752,092
1911	93,230	77,786	79,547,958	66,705,136
1912	91,864	77,363	83,351,191	67,461,513
1913	107,313	97,663	92,949,102	93,001,169
1914	68,311	63,358	89,049,766	82,204,096
1915	42,678	39,801	86,708,448	74,285,248
1916	(e)	(e)	92,363,335	101,378,755
1917	(e)	(e)	93,453,658	126,105,800
1918	(e)	(e)	71,514,629	113,847,675
	4,806,757	3,937,695	1,352,894,934	1,304,925,523

[a] Statistics by years or decades between 1818 and 1907 have been published in the chapters on cement in Mineral Resources for 1914, 1915, and 1916.
[b] First recorded output in 1870.
[c] Includes puzzolan cement.
[d] First recorded output in 1896.
[e] Included with natural cement.

PORTLAND CEMENT.

PRODUCTION AND SHIPMENTS.

The total production of Portland cement in the United States in 1918, as reported to the United States Geological Survey, was 71,081,663 barrels, valued at $113,446,334. This represents a decrease in quantity of 23.4 per cent and in value of about 9.7 per cent. The value assigned is computed at $1.596 a barrel, the average price of the Portland cement shipped in 1918.

The shipments of Portland cement from the mills in the United States in 1918 were, according to reports received by the Geological Survey, 70,915,508 barrels, valued in bulk at the mills at $113,153,513, compared with 90,703,474 barrels, valued at $122,775,088, in 1917—a decrease in quantity of 19,787,966 barrels, or 21.8 per cent, and a decrease in value of $9,621,575, or about 7.8 per cent.

The average price per barrel for the whole country in 1918, according to these figures, was $1.596, compared with $1.354 in 1917—an increase of 24.2 cents a barrel, or 17.9 per cent. This represents the

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selling price of cement in bulk at the mills and includes cost of labor and packing but not the value of the sacks or barrels. The average price per barrel for the country was 8.5 cents higher than the average price received for Portland cement in Pennsylvania, where it was lowest, and was near the average price received in Illinois, Indiana, Missouri, New York, and the following districts: Lehigh, Kentucky-southern Indiana, Ohio-western Pennsylvania, Maryland-Virginia-West Virginia, and Iowa-Minnesota-Missouri. It was 29.8 cents below the average received in Washington, where Portland cement brought the highest price of the year ($1.894). The average prices for State and district were nearer the general average price for the country in 1918 than in 1917. The quantity of Portland cement made in 1918 (71,081,663 barrels of 376 pounds) was approximately equivalent to 11,931,565 long tons, and the price per ton was about $9.51.

The average price of Portland cement in the United States is slightly above the average for ordinary gray cement on account of the inclusion in the total shipments of a small quantity of white Portland cement. This white cement was produced in the Lehigh district, so that the value for that district has been increased in greater proportion than that of the other districts. Two mills, both in Pennsylvania, reported the production of white Portland cement in 1918.

At the beginning of 1918 the rate of shipments of Portland cement from the mills was about 2,300,000 barrels a month, the lowest for the year. From January to April there was an increase to more than 8,500,000 barrels, followed by a slight decline in May and a recovery in June; then by a drop to about 7,000,000 barrels in July, and then by a slight rise in August, and, finally by a steady and rapid decline to less than 3,000,000 barrels in December. Production showed less fluctuation, beginning at about 3,300,000 barrels, reaching a maximum of nearly 8,000,000 barrels in June, and declining to about 4,200,000 barrels in December. The average monthly shipments and production in 1918 were, respectively, about 5,910,000 barrels and 5,923,000 barrels, compared with about 7,559,000 barrels and 7,735,000 barrels, respectively, in 1917. Stocks of finished cement in 1918 were highest in February, when they totaled about 12,250,000 barrels, and lowest in June and October, when they were less than 8,000,000 barrels, whereas at the beginning and end of the year they were about 10,350,000 barrels and 10,450,000 barrels, respectively.

PRODUCTION AND SHIPMENTS, BY STATES.

In the following table the production and shipments and the corresponding values of Portland cement for 1917 and 1918 are arranged by States in alphabetic order, provided there are three or more producers or shippers in a single State, or permission is given to publish figures where there are less than three. By the term "producer" is meant a Portland-cement manufacturing company, whether the company operates one or more plants. In the table the term "producing plant" is applied to a mill or group of mills located at one place and operated by one company, but each establishment at a different place is counted as a plant. There were producing plants in 27 States in 1917 and 26 States in 1918, but as a number of these States

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did not contain three or more plants it has been necessary to group together in this table several States that are not closely related geographically. This disadvantage is, however, compensated for in the table "Portland cement produced and shipped by districts," in which statistics are given for groups of States—generally not more than three—that are geographically related.

In all the States in which Portland cement was manufactured in 1918 there were decreases in both shipments and production as compared with the output in 1917, but the average factory price per barrel showed an increase in all the States. The net change for the whole country was a decrease in shipments of 19,787,966 barrels, or 21.8 per cent, and a decrease in production of 21,732,539 barrels, or 23.4 per cent. In 1918 production exceeded shipments by 166,155 barrels.

Portland cement produced and shipped in 1917 and 1918, by States.

[S=shipments; P=production.]

State.		Active plants.		1917		1918		Percentage of change in quantity, 1918.	Average factory price per barrel.	
		1917	1918	Quantity (barrels).	Value.	Quantity (barrels).	Value.		1917	1918
California	S.	9	10	5,659,547	$7,426,097	4,238,424	$7,091,789	−25.1	$1.312	$1.673
	P.	9	9	5,653,362		4,354,074		−23.0		
Illinois	S.	4	4	4,378,233	6,090,158	3,703,471	5,695,186	−15.4	1.391	1.538
	P.	4	4	4,659,990		3,594,038		−22.9		
Indiana	S.	5	5	8,148,678	11,084,930	6,205,326	9,580,563	−23.8	1.360	1.544
	P.	5	5	8,705,831		5,291,851		−39.2		
Iowa	S.	4	4	4,428,765	6,870,863	3,188,069	5,423,926	−28.0	1.551	1.701
	P.	4	4	4,626,141		3,626,455		−21.6		
Kansas	S.	8	7	3,772,884	5,271,721	2,586,834	4,219,203	−31.4	1.397	1.631
	P.	8	7	4,015,169		2,499,723		−37.7		
Michigan	S.	11	10	4,313,771	6,122,887	3,618,088	6,078,167	−16.1	1.419	1.680
	P.	11	10	4,688,899		3,554,872		−24.2		
Missouri	S.	5	5	5,800,988	8,248,007	4,515,695	7,132,470	−22.2	1.422	1.579
	P.	5	5	5,882,240		4,738,596		−19.4		
New Jersey	S.	3	2	2,397,069	2,962,592	(a)	(a)	(a)	1.236	(a)
	P.	2	2	2,449,876		(a)		(a)		
New York	S.	9	8	5,408,726	7,050,656	4,074,759	6,568,746	−24.7	1.304	1.612
	P.	9	8	5,417,530		4,095,588		−24.4		
Ohio	S.	5	5	1,565,394	2,328,432	1,289,887	2,208,119	−17.6	1.487	1.712
	P.	5	5	1,566,209		1,440,859		−8.0		
Oklahoma	S.	3	3	1,736,761	2,633,479	1,218,841	2,208,041	−29.8	1.516	1.807
	P.	3	3	1,772,466		1,246,515		−29.7		
Pennsylvania	S.	21	21	27,709,442	34,512,388	22,238,689	33,600,956	−19.7	1.246	1.511
	P.	21	21	27,752,838		22,628,901		−18.5		
Texas	S.	5	5	2,358,944	3,661,328	1,918,919	3,297,977	−18.7	1.552	1.719
	P.	5	5	2,436,398		1,971,867		−19.1		
Utah	S.	3	3	899,599	1,461,689	549,563	923,155	−38.9	1.625	1.680
	P.	3	3	929,730		570,310		−38.7		
Washington	S.	5	5	1,403,191	2,367,045	1,116,754	2,114,730	−20.4	1.687	1.894
	P.	5	5	1,513,792		931,489		−38.5		
Other States b	S.	18	18	10,721,482	14,682,816	10,459,159	17,015,485	−20.3	1.369	1.628
	P.	18	18	10,743,731		10,536,525		−20.1		
	S.	118	115	90,703,474	122,775,088	70,915,508	113,153,513	−21.8	1.354	1.596
	P.	117	114	92,814,202		71,081,663		−23.4		

a Included in "Other States."

b 1917: Alabama, Colorado, Georgia, Kentucky, Maryland, Minnesota, Montana, Nebraska, Oregon, Tennessee, Virginia, and West Virginia. 1918: Same States as in 1917, with New Jersey included and Nebraska excluded.

PRODUCTION AND SHIPMENTS, BY COMMERCIAL DISTRICTS.

The division of the cement-producing territory into 12 geographic units, termed "commercial districts," is based to some extent on the relations of the Portland-cement plants to their trade territory.

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These relations are, of course, governed largely by transportation facilities and rates, and in forming the districts it has been found advisable to divide Pennsylvania, Indiana, and Texas in order to group the plants commercially.

As shown in the accompanying table there were decreases in both shipments and production in all districts in 1918 as compared with the output of each in 1917, but the average factory price per barrel showed a general increase.

Portland cement produced and shipped in 1917 and 1918, by districts.

[S=shipments; P=production.]

Commercial district.		Active plants.		Shipments and production (barrels).			Average factory price per barrel.		
		1917	1918	1917	1918	Percentage of change, 1918.	1917	1918	Percentage of change, 1918.
Lehigh district (eastern Pennsylvania and western New Jersey)	S.	21	20	24,423,641	19,351,123	−20.8	$1.220	$1.519	+24.5
	P.	20	20	24,423,507	19,701,820	−19.3			
New York	S.	9	8	5,408,726	4,074,159	−24.7	1.304	1.612	+23.6
	P.	9	8	5,417,530	4,095,588	−24.4			
Ohio and western Pennsylvania	S.	8	8	7,248,264	6,231,702	−14.0	1.382	1.540	+11.4
	P.	8	8	7,345,416	6,439,179	−12.3			
Michigan and northeastern Indiana	S.	13	12	4,835,304	4,183,260	−13.5	1.427	1.670	+17.0
	P.	13	12	5,263,810	4,106,467	−22.0			
Kentucky and southern Indiana	S.	3	3	2,386,347	1,960,109	−18.9	1.352	1.618	+19.7
	P.	3	3	2,517,257	1,609,475	−36.1			
Illinois and northwestern Indiana	S.	5	5	10,233,233	7,894,542	−22.9	1.367	1.525	+11.6
	P.	5	5	10,927,990	7,169,038	−34.4			
Maryland, Virginia, and West Virginia	S.	5	5	3,109,098	2,308,198	−25.8	1.265	1.623	+28.3
	P.	5	5	3,122,036	2,281,629	−26.9			
Tennessee, Alabama, and Georgia	S.	5	5	3,686,359	3,092,425	−16.1	1.233	1.524	+23.6
	P.	5	5	3,676,354	2,990,734	−18.6			
Iowa, Minnesota, and Missouri	S.	10	10	11,510,753	8,712,597	−24.3	1.485	1.631	+9.8
	P.	10	10	11,774,381	9,478,051	−19.5			
Nebraska,[a] Kansas, Oklahoma, and central Texas	S.	16	14	7,405,415	5,365,848	−27.5	1.453	1.690	+16.3
	P.	16	14	7,710,365	5,370,181	−30.4			
Rocky Mountain States, (Colorado, Utah, Montana, and western Texas).	S.	7	8	3,197,284	2,175,874	−31.9	1,664	1.850	+11.2
	P.	7	8	3,261,675	2,288,953	−29.8			
Pacific Coast States (California, Oregon, and Washington)	S.	16	17	7,259,050	5,565,676	−23.3	1.399	1.730	+23.7
	P.	16	16	7,372,981	5,550,548	−24.7			
	S.	118	115	90,703,474	70,915,508	−21.8	1.354	1.596	+17.9
	P.	117	114	92,814,202	71,081,663	−23.4			

[a] No output in 1918.

Portland cement shipped from mills in the United States, 1911–1918.

Year.	Quantity (barrels).	Value.	Year.	Quantity (barrels).	Value.
1911	75,547,829	$63,762,368	1915	86,891,681	$74,756,674
1912	85,012,556	69,109,800	1916	94,552,296	104,258,216
1913	88,689,377	89,106,975	1917	90,703,474	122,775,088
1914	86,437,956	80,118,475	1918	70,915,508	113,153,513

LEHIGH DISTRICT.

The production of Portland cement in the Lehigh district, in eastern Pennsylvania and western New Jersey, in 1918 was 19,701,820 barrels, compared with 24,423,507 barrels in 1917—a decrease of 4,721,687 barrels, or 19.3 per cent. The shipments from mills in this district in 1918 amounted to 19,351,123 barrels, compared with

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24,423,641 barrels in 1917—a decrease of 5,072,518 barrels, or 20.8 per cent. (See fig. 67.) The total value of the Portland cement shipped from this district in 1918 was reported as $29,399,457, at an average price of $1.519 a barrel in bulk at the mills, as compared with $29,787,313, or $1.220 a barrel, in 1917. The production of white Portland cement from two plants in this district is included in the figures for 1918. As the average price reported for the white cement was considerably higher than that reported for ordinary gray cement,

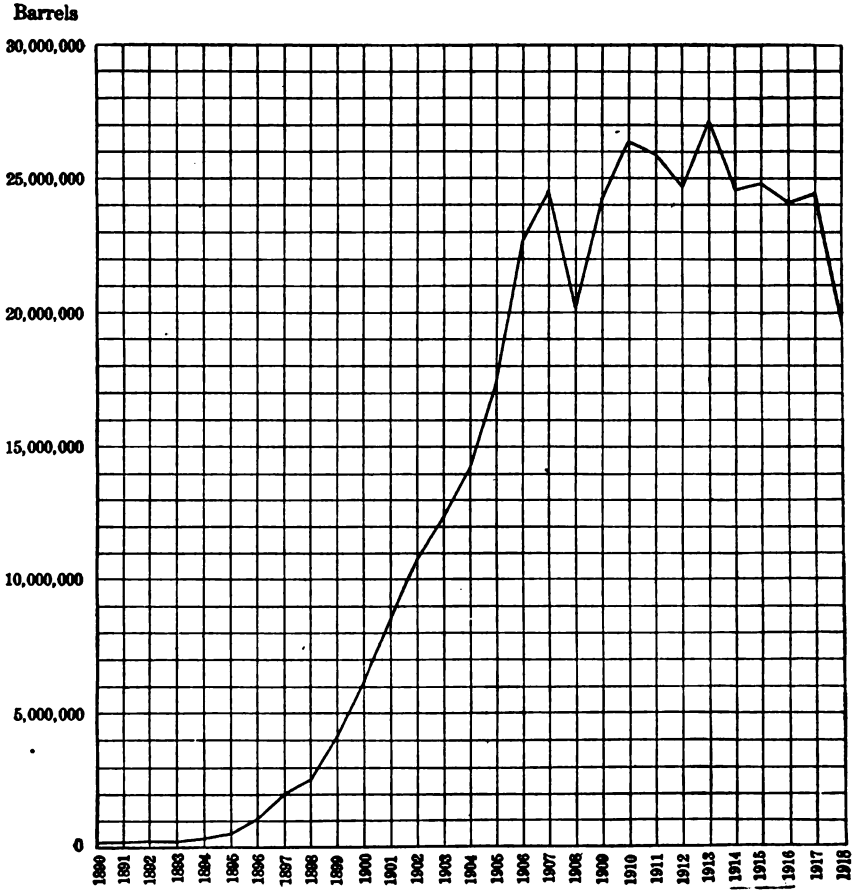

FIGURE 67.—Production of Portland cement in the Lehigh district, 1890-1918.

the average price for the district is slightly higher than if it represented gray Portland cement alone.

Twenty plants produced and shipped Portland cement from the Lehigh district in 1918, as compared with 20 producers and 21 shippers in 1917.

The Lehigh district produced 27.7 per cent of the total output of Portland cement in the United States in 1918. In 1897 this district produced 74.8 per cent of the total for the United States.

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Portland cement produced in the Lehigh district and in the United States, 1890–1918.

Year.	Lehigh district (barrels).	United States (barrels).	Percentage made in Lehigh district.	Year.	Lehigh district (barrels).	United States (barrels).	Percentage made in Lehigh district.
1890	201,000	335,500	60.0	1905	17,368,687	35,246,812	49.3
1891	248,500	454,813	54.7	1906	22,784,613	46,463,424	49.0
1892	280,840	547,440	51.3	1907	24,417,686	48,785,390	50.0
1893	265,317	590,652	44.9	1908	20,200,387	51,072,612	39.6
1894	485,329	798,757	60.8	1909	24,246,706	64,991,431	37.3
1895	634,276	990,324	64.0	1910	26,315,359	76,549,951	34.4
1896	1,048,154	1,543,023	68.1	1911	25,972,108	78,528,637	33.1
1897	2,002,059	2,677,775	74.8	1912	24,762,083	82,438,096	30.0
1898	2,674,304	3,692,284	72.4	1913	27,139,601	92,097,131	29.5
1899	4,110,132	5,652,266	72.7	1914	24,614,933	88,230,170	27.9
1900	6,153,629	8,482,020	72.6	1915	24,876,442	85,914,907	29.0
1901	8,596,340	12,711,225	67.7	1916	24,105,381	91,521,198	26.3
1902	10,829,922	17,230,644	62.8	1917	24,423,507	92,814,202	26.3
1903	12,324,922	22,342,973	55.2	1918	19,701,820	71,081,663	27.7
1904	14,211,039	26,505,881	53.7				

STOCKS AT MILLS.

The stock of Portland cement reported on hand at the various mills at the end of 1918 amounted to 10,453,950 barrels, compared with 10,353,838 barrels on hand at the end of 1917—an increase in stock of 100,112 barrels, or 1 per cent, during 1918. The reports of stocks at a few mills in 1917 were revised by the producers, at the request of the Geological Survey, and the stock reported for 1918 checks with the revised total for 1917 within 0.63 per cent of the stock calculated by balancing the shipments for 1918 against the production of 1918, plus the stock at the close of 1917. This agreement is sufficiently close, considering that the volume of stocks can not be measured with great accuracy.

Portland cement in stock Dec. 31, 1917, and Dec. 31, 1918, by States.

State.	Quantity (barrels).		Percentage of change in 1918.
	1917 (revised).	1918	
California	463,256	528,026	+ 14.0
Illinois	739,763	646,255	− 12.6
Indiana	1,760,532	822,888	− 53.3
Iowa	618,811	1,055,540	+ 70.6
Kansas	409,393	326,273	− 20.3
Michigan	701,919	635,447	− 9.3
Missouri	404,624	676,552	+ 67.2
New Jersey	237,554	(a)	(a)
New York	804,811	832,271	+ 3.4
Ohio	126,239	262,142	+107.7
Oklahoma	70,708	89,188	+ 26.1
Pennsylvania	2,455,588	2,840,810	+ 15.7
Texas	222,537	289,779	+ 30.2
Utah	106,580	133,465	+ 25.2
Washington	385,707	214,220	− 44.5
Other States b	845,816	1,101,094	+ 1.6
	10,353,838	10,453,950	+ 1.0

a Included in "Other States."
b 1917: Alabama, Colorado, Georgia, Kentucky, Maryland, Minnesota, Montana, Nebraska, Oregon, Tennessee, Virginia, and West Virginia. 1918: Same States as in 1917, with New Jersey included and Nebraska excluded.

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Portland cement in stock Dec. 31, 1917, and Dec. 31, 1918, by districts.

District.	Quantity (barrels).		Percentage of change in 1918.
	1917 (revised).	1918	
Lehigh district (New Jersey and eastern Pennsylvania)	2,166,106	2,512,123	+ 16.0
New York	804,811	832,271	+ 3.4
Ohio and western Pennsylvania	653,275	845,373	+ 29.4
Michigan and northeastern Indiana	870,544	790,495	− 9.2
Kentucky and southern Indiana	611,426	246,242	− 59.7
Illinois and northwestern Indiana	1,823,967	1,088,775	− 40.3
Maryland, Virginia, and West Virginia	305,948	268,384	− 12.3
Tennessee, Alabama, and Georgia	220,582	118,988	− 46.1
Iowa, Minnesota, and Missouri	1,124,854	1,937,902	+ 72.3
Kansas, Nebraska,[a] Oklahoma, and central Texas	642,191	654,876	+ 2.0
Rocky Mountain States (Colorado, Utah, Montana, and western Texas)	255,056	375,042	+ 47.0
Pacific Coast States (California, Oregon, and Washington)	875,078	783,479	− 10.5
	10,353,838	10,453,950	+ 1.0

[a] No stock in 1918.

Portland cement in stock in the United States at the end of the years 1911 to 1918.

	Barrels.		Barrels.
1911	10,385,789	1915	11,462,523
1912	7,811,329	1916	8,360,552
1913	11,220,328	1917	10,353,838
1914	12,773,463	1918	10,453,950

DOMESTIC CONSUMPTION OF PORTLAND CEMENT.

An estimate of the total consumption of Portland cement in the United States may be made by adding the imports to the shipments and subtracting the exports from the sum. Of course, a variable but considerable stock of cement is at all times in transit, in warehouses at distributing points, and awaiting use on the ground at large jobs, so that the estimate thus made is at best approximate. Still another uncertain element in this estimate is the fact that as imports and exports are classed as hydraulic cement the records do not discriminate between Portland and other cements. Portland cement, however, constitutes by far the greater part of the exports, and, as the tables show, the imports are small. The apparent domestic consumption in 1918 amounted to 68,663,367 barrels, compared with 88,119,582 barrels in 1917, a decrease of 19,456,215 barrels or about 22 per cent, as compared with a decrease of 4 per cent in 1917.

The following table gives the figures necessary for estimates of consumption so far as available, as prior to 1911 no records are at hand for stocks:

Apparent domestic consumption of Portland cement, 1911–1918, in barrels.

Year.	Shipments.	Imports.	Exports.	Apparent consumption.
1911	75,547,829	164,670	3,135,409	72,577,090
1912	85,012,556	68,503	4,215,532	80,865,527
1913	88,089,377	85,470	2,964,358	85,810,489
1914	86,437,956	120,906	2,140,197	84,418,665
1915	86,891,681	42,218	2,565,031	84,368,868
1916	94,552,296	1,836	2,563,976	91,990,156
1917	90,703,474	2,323	2,586,215	88,119,582
1918	70,915,508	305	2,252,446	68,663,367

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PORTLAND CEMENT CONSUMED PER CAPITA.

In estimating the consumption of Portland cement in the States and the dependencies of the United States, the consumption by political divisions is, of course, not absolute, as it is represented only by the records of shipments by manufacturers into the several States. Also, the shipments of cement into a State do not equal the consumption in that State during the same period, but if taken for a long period they should afford a very fair index to that consumption.[1] The consumption in the outlying possessions of the United States is represented simply by the official statistics of exports to those countries from the United States and do not include small imports that may have come from foreign countries. The table of exports to other countries on page 587 shows the shipments of cement from the United States to the Philippines, but there are no data available as to the imports of cement to the islands from foreign countries, which of course, should figure in their per capita consumption. The simplest available common index appears to be the estimated consumption per capita in barrels, which has been obtained by comparing the shipments into States and possessions with the population for the States and possessions in 1917 and 1918, as estimated by the Bureau of the Census.

There is a discrepancy between the official figures of the Bureau of Foreign and Domestic Commerce for exports of cement, given on page 587, and the exports reported by manufacturers, as given in the following table, owing to the fact that cement shipped from mills destined for foreign countries is reported by the shipper as exported, whether or not it leaves the country during that calendar year, but the Bureau of Foreign and Domestic Commerce bases its export figures on the cement that actually leaves the country, according to its records. The exports given by that bureau include all natural or puzzolan cement which may have been exported, whereas the table of per capita consumption given below relates only to Portland cement. Another source of apparent disagreement is the fact that the lump figure for unspecified exports reported by manufacturers does not include the exports to Alaska, Hawaii, and Porto Rico, statistics for which are given separately in the same table.

The per capita consumption shown by the table necessarily falls short of the total apparent consumption by the quantity of the imports. These, however, are small—only 2,323 barrels in 1917 and 305 barrels in 1918.

The highest per capita consumption in 1918 was that of the District of Columbia, 1.61 barrels. The next seven divisions in which the per capita consumption was more than 1 barrel were Delaware (1.24), California (1.16), Arizona (1.09), Maryland (1.05), Michigan (1.04), Iowa (1.03), and Wyoming (1.02). In 1917 Montana showed the highest per capita consumption, 1.69 barrels. Nineteen States in 1917 exceeded a per capita consumption of 1 barrel, and 17 States in 1916. Of the 8 States that consumed more than 1 barrel of Portland cement per capita in 1918, 4 were west of Mississippi River, compared with 10 in 1917. Comparison of the figures by States shows that all of the 52 divisions showed some change in per capita consumption, 8 having shown an increase and 44 a decrease. The increases were moderate, the most noteworthy having been in Virginia,

[1] Data on per capita consumption of Portland cement by States beginning with the year 1914 are available in preceding volumes of Mineral Resources.

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from 0.61 to 0.93 barrels; Delaware, from 0.99 to 1.24; and the District of Columbia, from 1.38 to 1.61. The general average per capita consumption was 0.64 barrel in 1918, compared with 0.84 barrel in 1917.

Estimated per capita consumption of Portland cement in the United States and outlying possessions in 1917 and 1918.

State.	1917			1918		
	Population (estimated).	Consumption (shipments to States).	Estimated consumption per capita.	Population (estimated).	Consumption (shipments to States).	Estimated consumption per capita.
		Barrels.	*Bbls.*		*Barrels.*	*Bbls.*
Alabama	2,363,939	467,823	0.20	2,395,270	839,891	0.35
Alaska	64,912	14,953	.23	64,990	7,008	.11
Arizona	263,788	385,520	1.46	272,034	297,849	1.09
Arkansas	1,766,343	344,240	.19	1,792,965	303,304	.17
California	3,029,032	4,608,011	1.52	3,119,412	3,606,286	1.16
Colorado	988,320	766,926	.78	1,014,581	584,760	.58
Connecticut	1,265,373	1,451,454	1.15	1,286,268	930,420	.72
Delaware	215,160	213,281	.99	216,941	269,249	1.24
District of Columbia	369,282	510,296	1.38	374,584	602,666	1.61
Florida	916,185	523,997	.57	938,877	388,241	.41
Georgia	2,895,841	799,207	.28	2,935,617	717,800	.24
Hawaii	219,580	327,971	1.49	223,419	112,230	.50
Idaho	445,176	367,776	.83	461,766	212,022	.46
Illinois	6,234,995	7,189,662	1.15	6,317,734	4,925,736	.78
Indiana	2,835,492	3,425,053	1.21	2,854,167	2,406,617	.84
Iowa	2,224,771	3,501,871	1.57	2,224,771	2,298,157	1.03
Kansas	1,851,870	1,977,798	1.07	1,874,195	1,422,877	.76
Kentucky	2,394,093	963,314	.40	2,408,547	633,642	.26
Louisiana	1,856,954	612,710	.33	1,884,778	587,208	.31
Maine	777,340	376,236	.48	782,191	247,345	.32
Maryland	1,373,673	1,552,333	1.13	1,384,539	1,449,446	1.05
Massachusetts	3,775,973	2,800,769	.74	3,832,790	2,225,422	.58
Michigan	3,094,266	4,425,533	1.43	3,133,678	3,266,393	1.04
Minnesota	2,312,445	2,793,371	1.21	2,345,287	2,164,947	.92
Mississippi	1,976,570	251,523	.13	2,001,466	165,061	.08
Missouri	3,429,595	2,548,152	.74	3,448,498	1,652,454	.48
Montana	472,035	800,997	1.69	486,376	369,206	.76
Nebraska	1,284,126	1,469,201	1.14	1,296,377	1,101,593	.85
Nevada	110,738	79,774	.72	114,742	37,765	.33
New Hampshire	444,429	313,154	.70	446,352	225,774	.51
New Jersey	3,014,194	3,120,589	1.04	3,080,371	2,869,894	.93
New Mexico	423,649	161,742	.38	437,015	132,756	.30
New York	10,460,182	8,920,808	.85	10,646,989	6,319,045	.59
North Carolina	2,434,381	1,030,295	.42	2,466,025	648,403	.26
North Dakota	765,319	410,687	.54	791,437	291,248	.37
Ohio	5,212,085	6,950,672	1.33	5,273,814	5,010,482	.95
Oklahoma	2,289,855	1,443,928	.63	2,377,029	1,118,595	.47
Oregon	861,992	410,701	.48	988,243	324,764	.37
Pennsylvania	8,660,042	7,787,055	.90	8,798,067	6,611,108	.75
Porto Rico	1,231,880	242,703	.20	1,247,677	188,728	.15
Rhode Island	625,865	332,272	.53	637,415	343,182	.54
South Carolina	1,643,205	501,405	.31	1,660,934	715,483	.43
South Dakota	716,972	537,983	.75	735,434	435,485	.59
Tennessee	2,304,629	889,456	.39	2,321,253	943,349	.41
Texas	4,515,423	2,034,548	.45	4,601,279	1,509,318	.33
Utah	443,866	526,086	1.19	453,648	350,603	.77
Vermont	364,946	179,973	.49	366,192	122,477	.33
Virginia	2,213,025	1,347,254	.61	2,234,030	2,073,385	.93
Washington	1,597,400	1,189,880	.74	1,660,578	1,044,898	.63
West Virginia	1,412,602	1,187,499	.84	1,439,165	1,257,954	.87
Wisconsin	2,527,167	2,964,196	1.17	2,553,983	2,230,895	.87
Wyoming	184,970	276,815	1.50	190,380	193,922	1.02
Unspecified	.....	41,239	.....	.....	2,904	.....
	105,156,845	88,351,192	.84	106,795,270	68,790,247	.64
Exports reported by manufacturers but not included above	.....	2,352,282	.....	.....	2,125,261	.....
Total shipped from cement plants	.....	90,703,474	.....	.....	70,915,508	.....

In connection with the study of consumption of cement it is of interest to compare the shipments from the mills within a State or group of States with the estimated cement consumption of that area

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and thus to ascertain the extent of the surplus or deficiency in the supply of cement locally available. The following table has therefore been arranged with that in view. (Data for 1916 will be found in the chapter in Mineral Resources on cement in 1917.) The second table shows how much of the surplus product was consumed by each of the non cement-producing States and dependencies.

Estimated surplus or deficiency in local supply of Portland cement in cement-producing States, 1917–18, in barrels.

State or division.	1917			1918		
	Shipments from mills.	Estimated consumption.	Surplus or deficiency.	Shipments from mills.	Estimated consumption.	Surplus or deficiency.
California	5,659,547	4,608,011	+ 1,051,536	4,238,424	3,606,286	+ 632,138
Illinois	4,378,233	7,189,062	− 2,811,429	3,703,471	4,925,736	− 1,222,265
Indiana	8,148,678	3,425,053	+ 4,723,625	6,205,326	2,406,617	+ 3,798,709
Kansas	3,772,884	1,977,798	+ 1,795,086	2,586,834	1,422,877	+ 1,163,957
Michigan	4,313,771	4,425,533	− 111,762	3,618,088	3,266,393	+ 351,695
Missouri	5,800,988	2,548,152	+ 3,252,836	4,515,695	1,652,454	+ 2,863,241
New Jersey	2,397,069	3,120,589	− 723,520	(a)	(a)	(a)
New York	5,408,726	8,920,808	− 3,512,082	4,074,159	6,319,045	− 2,244,886
Ohio	1,565,394	6,950,672	− 5,385,278	1,289,887	5,010,432	− 3,720,595
Oklahoma	1,736,761	1,443,928	+ 292,833	1,218,841	1,118,595	+ 100,246
Pennsylvania	27,703,442	7,787,055	+19,922,387	22,238,689	6,611,108	+15,627,581
Texas	2,358,944	2,034,548	+ 324,396	1,918,919	1,509,318	+ 409,601
Utah	899,599	526,086	+ 373,513	549,583	350,603	+ 198,990
Washington	1,403,191	1,189,880	+ 213,311	1,116,754	1,044,898	+ 71,856
Maryland, Virginia, and West Virginia	3,109,068	4,087,586	− 978,488	b4,362,442	b7,650,679	−b3,288,237
Tennessee and Kentucky	2,628,388	1,852,770	+ 775,618	2,254,277	1,576,991	+ 677,286
Alabama and Georgia	1,672,173	1,267,030	+ 405,143	1,349,174	1,557,691	− 208,517
Iowa, Minnesota, and Nebraska[c]	5,731,652	7,764,443	− 2,032,791	4,196,902	5,564,697	− 1,367,795
Colorado, Montana, and Oregon	2,008,936	1,978,624	+ 30,312	1,478,033	1,278,730	+ 199,303
	90,703,474	73,098,228	+17,605,246	70,915,508	56,873,200	+14,042,308

[a] Included with Maryland, Virginia, and West Virginia.
[b] Includes also New Jersey in 1918.
[c] Nebraska had no output in 1918.

Estimated consumption of Portland cement in non cement-producing States, 1917–18, in barrels.

State.	1917	1918
Alaska	14,953	7,008
Arizona	385,520	297,849
Arkansas	344,240	303,304
Connecticut	1,451,454	930,420
Delaware	213,281	269,249
District of Columbia	510,296	602,666
Florida	528,997	388,241
Hawaii	327,971	112,230
Idaho	367,776	212,022
Louisiana	612,710	587,208
Maine	376,236	247,345
Massachusetts	2,800,769	2,225,422
Mississippi	251,523	165,061
Nevada	79,774	37,765
New Hampshire	313,154	225,774
New Mexico	161,742	132,756
North Carolina	1,030,295	648,403
North Dakota	410,687	291,248
Porto Rico	242,703	188,728
Rhode Island	332,272	343,182
South Carolina	501,405	715,483
South Dakota	537,983	435,485
Vermont	179,973	122,477
Wisconsin	2,964,196	2,230,895
Wyoming	276,815	193,922
Unspecified	41,239	2,904
	15,252,964	11,917,047
Exports to foreign countries	2,352,282	2,125,261
Surplus from cement-producing States	17,605,246	14,042,308
Consumption in cement-producing States	73,098,228	56,873,200
Total shipments	90,703,474	70,915,508

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Among the cement-producing States or groups of States there are, of course, fewer deficiencies than surpluses, and certain of the deficiencies indicated are due to local conditions. For instance, in 1918 Illinois showed a deficiency of more than 1,200,000 barrels, while Indiana showed a surplus of more than 3,798,000 barrels. This is equalized in large part by the flow of cement from northeastern Indiana into the adjacent populous Chicago district in Illinois. Ohio showed a deficiency of about 3,720,000 barrels, which was largely supplied from Pennsylvania's surplus of more than 15,500,000 barrels. New York State, though a large producer, has a large deficiency, which is mostly supplied from the Lehigh district. The Iowa-Minnesota-Nebraska group showed a deficiency of more than 1,300,000 barrels in 1918, but the deficiency has rapidly decreased in the last few years, indicating that it will soon be overtaken by local production. The quantities consumed in the nonproducing States and dependencies are of interest in comparison with the other data. More than 500,000 barrels were consumed in 1918 in the District of Columbia and in each of the States of Connecticut, Louisiana, North Carolina, and South Carolina; and Massachusetts and Wisconsin each consumed more than 2,000,000 barrels; but the per capita consumption in all these States is a better index to the relative consumption than the total figures. The quantity consumed in the nonproducing States plus the unspecified quantities and the exports amounted in 1918 to 14,042,308 barrels, compared with 17,605,246 barrels in 1917, and in 1918 this total represented 19.8 per cent of the total shipments from mills in the United States.

PRICES.

Average prices of Portland cement sold in bulk at the factories as reported to the Geological Survey are shown in the tables of shipments by States and districts during 1917 and 1918, pages 572–573. According to these figures the average prices in 1918 ranged between $1.511 a barrel in Pennsylvania and $1.894 a barrel in Washington, as compared with $1.22 cents in the Lehigh district and $1.69 in Washington in 1917. The general average price for the whole country was $1.596 in 1918, compared with $1.354 in 1917, an increase of 24.2 cents per barrel, or 17.9 per cent. This is the highest average price that has been realized since 1898. The States whose increases were more than 25 cents per barrel were California, 36 cents; Michigan, 26 cents; New York, 31 cents; Oklahoma, 29 cents; Pennsylvania, 26.5 cents. All the districts, as well as every State, showed an increase in average price. The district average prices are, of course, nearer the general average than the State average prices.

The following prices on Portland cement at certain shipping points were quoted to the United States Government by the cement industry in 1917 and 1918. These prices were based on the understanding that the Government requirements would be small—less than 5 per cent of the total output—and that the price to the Government should not control the price to the trade. It was deemed possible to make these prices to the Government because of the fact that the burden, admittedly small, would also be evenly distributed, so that when the quota of the mills in a locality had been supplied any additional cement would have to be shipped from the nearest locality whose quota

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had not been exhausted, and the price would then be the base price of the shipping locality plus the freight to the point of delivery.

The following prices per barrel exclusive of packages were accepted by the War Industries Board:

Prices of Portland cement to the United States Government at different shipping points, 1917 and 1918.

Place.	1917 and first four months of 1918.	Second four months of 1918.	Third four months of 1918.	Place.	1917 and first four months of 1918.	Second four months of 1918.	Third four months of 1918.
Hudson, N. Y.	$1.40	$1.85	$1.82	Portland, Colo.	$1.70	$1.75	$1.72
Lehigh Valley, Pa.	1.30	.....	.....	Devils Slide, Utah	.....	1.90	1.87
Northampton, Pa.	.....	1.75	1.72	Brigham, Utah	.....	1.90	1.87
Pittsburgh, Pa.	1.50	.....	.....	Salt Lake, Utah	.....	1.90	1.87
Universal, Pa.	.....	1.75	1.72	Trident, Mont.	1.70	1.90	1.87
Fordwick, Va.	1.40	1.70	1.67	Irvin, Wash.	1.70	1.95	1.92
Bellevue, Mich.	1.50	1.80	1.77	Concrete, Wash.	.....	1.95	1.92
Mitchell, Ind.	1.50	1.70	1.67	Seattle, Wash.	1.90	.....	.....
Hannibal, Mo.	1.50	1.70	1.67	Tacoma, Wash.	1.70	.....	.....
Buffington, Ind.	1.40	1.60	1.57	Portland, Oreg.	1.70	.....	.....
La Salle, Ill.	.....	1.70	1.67	Oswego, Oreg.	.....	2.00	1.97
Mason City, Iowa	1.55	1.70	1.67	Cement, Calif.	.....	1.95	1.92
Iola, Kans.	1.50	1.75	1.72	Stockton, Calif.	1.70	.....	.....
Steelton, Minn.	1.55	1.70	1.67	Oakland, Calif.	1.70	.....	.....
Kingsport, Tenn.	1.40	1.65	1.62	San Francisco, Calif.	1.70	.....	.....
Richard City, Tenn.	1.40	1.65	1.62	Davenport, Calif.	.....	1.95	1.92
Harrys, Tex.	1.30	1.70	1.67	Santa Cruz, Calif.	1.70	.....	.....
Houston, Tex.	1.40	1.80	1.77	Santa Barbara, Calif.	1.70	.....	.....
El Paso, Tex.	1.90	1.95	1.92	Los Angeles, Calif.	1.70	.....	.....
San Antonio, Tex.	.....	1.95	1.92	Crestmore, Calif.	.....	1.95	1.92
New Orleans, La.	1.78	.....	.....				

The cement prices established for the last four months of 1918 are apparently a downward revision of 3 cents a barrel from the former prices, but the new prices were for cement without bin inspection. A charge of 3 cents, however, was allowed for bin inspection, and as most purchasers required inspection to be made, there was practically no change in cement prices.

Figure 68 illustrates graphically the rapid early decline and the recent fluctuations in the general average factory prices of Portland cement, and the following table summarizes the same data:

Average factory price per barrel in bulk of Portland cement, 1870–1918.

1870–1880	$3.00	1895	$1.60	1907	$1.11
1881	2.50	1896	1.57	1908	.85
1882	2.25	1897	1.61	1909	.813
1883	2.15	1898	1.62	1910	.891
1884	2.10	1899	1.43	1911	.844
1885–1888	1.95	1900	1.09	1912	.813
1889	1.67	1901	.99	1913	1.005
1890	2.09	1902	1.21	1914	.927
1891	2.13	1903	1.24	1915	.860
1892	2.11	1904	.88	1916	1.103
1893	1.96	1905	.94	1917	1.354
1894	1.73	1906	1.13	1918	1.596

MARKET PRICES.

An interesting compilation of wholesale prices of cement by months, quarters, and years, 1913–1918, for various portions of the United States has recently been published by the War Industries

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Board.[1] Where the prices quoted can be compared directly with those reported to the Geological Survey from the mills in a given State it is found that there is no great difference in yearly averages.

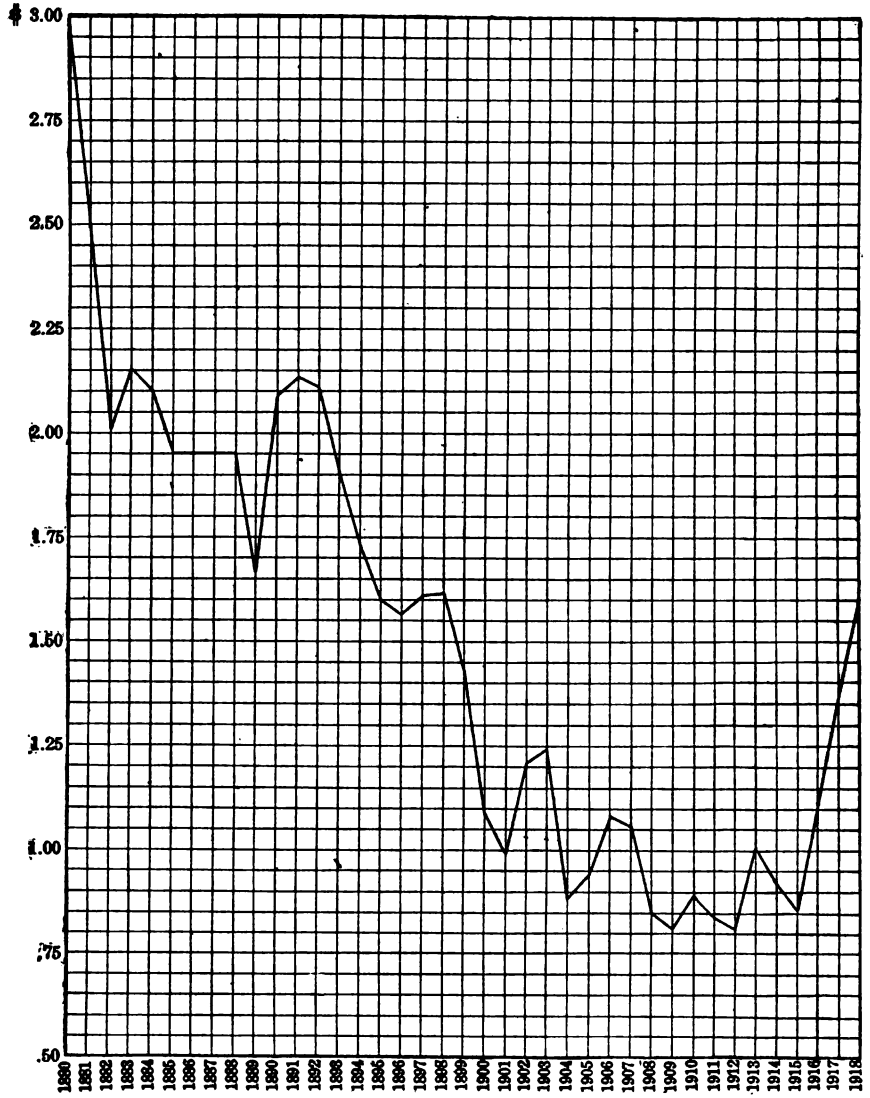

FIGURE 68.—Range in average factory price per barrel of Portland cement, 1880–1918.

Wholesale prices at the end of the war, however, had reached much higher figures than the factory prices. Cement prices are shown on a chart to have risen from a basis of 100 in 1913–14 to about 175 at the signing of the armistice in 1918, as compared with a maximum of

[1] Prices of cement: War Industries Board Price Bull. 41, pp. 8–9, 1919.

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more than 200 for "all commodities." The price of cement is also stated not to have risen so rapidly as the prices of other building materials.

MANUFACTURING CONDITIONS.

PLANTS.

Portland cement was manufactured at 114 plants and shipments were made from 115 plants in 1918, as compared with 117 producing plants and 118 shipping plants in 1917—a net decrease of 3 producing and 3 shipping plants.

Six plants manufactured no cement during the year—one each in California, Kansas, Michigan, Nebraska, New Jersey, and New York, but the idle plant in California shipped cement from stock. One plant in New Jersey that shipped only from stock in 1917 resumed production in 1918. Two new plants produced Portland cement in 1918—the Old Mission, at San Juan de Bautista, Calif., and the Three Forks, at Hanover, Mont.

The new plants that began operations are equipped as follows:

Old Mission Portland Cement Co., plant at San Juan, Benito County, Calif. Wet process; limestone, clay, and shale; clinker burned with oil; four 8-by-150-foot kilns; daily clinker capacity, 2,000 barrels.

Three Forks Portland Cement Co., plant at Hanover, Fergus County, Mont. Wet process; limestone; clinker burned with coal; one 9-by-200-foot kiln; daily clinker capacity, 1,000 barrels.

KILNS.

The total number of rotary kilns reported in plants that operated in 1918 was 749, compared with 789 in 1917—a net decrease of 40 kilns. The number of active small kilns, 40 to 60 feet long, was decreased by 31; kilns between 60 and 100 feet long decreased by 4; 100-foot kilns increased by 21; 110-foot kilns decreased by 18; kilns 120 feet long remained the same in number; kilns 125 feet long decreased by 11; kilns 125 to 140 feet long decreased by 11; and kilns 150 feet or more in length increased by 5. The increase in the larger kilns is the natural trend in a period in which prevailed high manufacturing costs, together with a subnormal demand.

Lengths of rotary cement kilns in active plants in the United States, 1915–1918.

Length (feet).	Number of kilns.				Length (feet).	Number of kilns.			
	1915	1916	1917	1918		1915	1916	1917	1918
40 to 60	99	128	108	77	126 to 149	63	62	65	63
61 to 99	124	119	94	90	150 to 199	47	69	73	68
100 to 109	86	81	84	105	200 to 260				15
110	88	89	83	65					
120	99	109	88	88		754	807	789	749
125	148	150	194	183					

KILN FUELS.

A summary of kiln fuels reported in 1918 shows that 93 plants, employing 605 kilns, burned powdered coal; that 16 plants, employing 99 kilns, burned crude oil. At certain plants more than one

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fuel is used. For instance, 2 plants reported coal and oil; 1 plant, coal and gas; and 2 plants, oil, coal, and gas. The percentage of cement burned by coal increased slightly.

Summary of Portland cement kiln fuels in 1917 and 1918.

Fuel.	1917				1918			
	Number of plants.	Number of kilns.	Barrels of cement.	Percentage of total.	Number of plants.	Number of kilns.	Barrels of cement.	Percentage of total.
Coal	93	636	76,410,379	82.2	93	605	58,605,244	82.4
Coal and crude oil	1	24	6,492,713	7.0	2	28	5,188,915	7.3
Coal and gas	2	14			1	4		
Crude oil	18	103	8,680,313	9.4	16	99	6,442,165	9.1
Crude oil, coal, and gas	1	5	1,230,797	1.4	2	13	845,339	1.2
Producer gas	1	1			.....	.....	.....	.....
Natural gas	1	6			.....	.....	.....	.....
	117	789	92,814,202	100.0	114	749	71,081,663	100.0

CAPACITY.

The total annual kiln capacity in the United States in 1918 of all the plants, either active or only temporarily closed, according to manufacturers' reports, was approximately 138,400,000 barrels of Portland cement, compared with about 136,750,000 barrels in 1917—an increase of 1,650,000 barrels, or 1.2 per cent. According to these figures the total production of cement in 1918 (71,081,663 barrels) was about 51 per cent of the total capacity, whereas the production in 1917 represented about 68 per cent of the apparent total capacity in that year.

Based on the reported kiln capacities, the following table of estimated capacities by districts has been prepared, and these figures, compared with the respective figures of production, give the apparent percentage of capacity utilized in 1917 and 1918.

Annual Portland cement manufacturing capacity of the United States, by commercial districts, 1917 and 1918.

District.	Estimated capacity (barrels).		Per cent of capacity utilized.	
	1917	1918	1917	1918
Lehigh district (eastern Pennsylvania and western New Jersey)	37,016,132	36,904,000	66.0	53.4
New York	8,552,480	8,411,400	63.3	48.7
Ohio and western Pennsylvania	9,379,040	12,983,000	78.3	49.6
Michigan and northeastern Indiana	8,672,400	7,770,000	60.7	52.9
Southern Indiana and Kentucky	4,336,200	4,550,000	58.1	35.4
Illinois and northwestern Indiana	13,859,780	14,060,000	78.8	51.0
Maryland, Virginia, and West Virginia	4,384,380	4,322,200	71.2	52.7
Tennessee, Alabama, and Georgia	4,657,400	4,500,000	78.9	66.5
Iowa, Missouri, and Minnesota	13,764,480	14,040,000	85.5	67.5
Nebraska,[a] Kansas, Oklahoma, and central Texas	12,197,570	10,579,500	63.2	50.8
Rocky Mountain States (Colorado, Utah, Montana, and western Texas)	4,336,200	4,498,000	75.2	50.9
Pacific Coast States (California, Washington, and Oregon)	15,594,260	15,783,100	47.3	35.2
	136,750,322	138,401,200	67.9	51.3

[a] Nebraska had no output in 1918.

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RECOVERY OF POTASH.

The production of potash salts as a by-product of the manufacture of Portland cement continued during 1918 to be a subject of interest to the cement industry in view of the shortage in potash and the military needs for it. At the end of 1918 the production of potash salts was reported by 12 cement plants—3 of them in California, 1 in Indiana, 1 in Maryland, 1 in Michigan, 1 in New York, 3 in Pennsylvania, and 2 in Utah. At the same time 4 plants reported the construction of apparatus for the recovery of potash under way, and 13 plants reported that this recovery was under consideration. In 1917 there were 7 plants producing potash salts and about the same number reported apparatus under construction. In 1918 the quantity of potash (K_2O) produced by cement plants was 1,549 short tons, valued at $603,617—a slight decrease in quantity as compared with the output in 1917.[1]

Recovery of potash at Portland cement plants in the United States in 1918.

Plant and location.	In operation.	Under construction.	Under consideration.	Type of process.
California Portland Cement Co., Colton, Calif.	Yes			Leaching and evaporation.
Golden State Portland Cement Co., Oro Grande, Calif.		Yes		
Pacific Portland Cement Co., Cement, Calif.		Yes		
Riverside Portland Cement Co., Riverside, Calif.	Yes			Cottrell (Huber and Reath patents).
Southwestern Portland Cement Co., Victorville, Calif.	Yes			Leaching and evaporation (washing gases).
Sandusky Portland Cement Co., Dixon, Ill.			Experimenting.	Wet.
Louisville Cement Co., Speeds, Ind.	Yes			Direct extraction from shale.
Bonner Portland Cement Co., Bonner Springs, Kans.			Yes	
Western States Portland Cement Co., Independence, Kans.			Yes	
Security Cement & Lime Co., Security, Md.	Yes			Cottrell.
Aetna Portland Cement Co., Fenton, Mich.			Yes	
Michigan Portland Cement Co., Chelsea, Mich.			Yes	
Newaygo Portland Cement Co., Newaygo, Mich.	Yes			Do.
Peninsular Portland Cement Co., Cement City, Mich.			Yes	
Alpha Portland Cement Co., Cementon, N. Y.	Yes			Do.
Alpha Portland Cement Co., Jamesville, N. Y.			Yes	
Helderberg Cement Co., Howes Cave, N. Y.			Yes	
Castalia Portland Cement Co., Castalia, Ohio.			Yes	
Ironton Portland Cement Co., Ironton, Ohio.		Yes		
Oklahoma Portland Cement Co., Ada, Okla.			Yes	
Alpha Portland Cement Co., Martins Creek, Pa.	Yes			Collected in waste heat dust.
Coplay Cement Manufacturing Co., Coplay, Pa.	Yes			Cottrell.
Dexter Portland Cement Co., Nazareth, Pa.	Yes			Do.
Nazareth Cement Co., Nazareth, Pa.			Yes	
Penn-Allen Cement Co., Penn-Allen, Pa.			Yes	
Clinchfield Portland Cement Corporation, Kingsport, Tenn.		Yes		Do.
Trinity Portland Cement Co., Eagle Ford, Tex.			Yes	
Ogden Portland Cement Co., Bakers, Utah.	Yes			Wet.
Portland Cement Co. of Utah, Salt Lake City, Utah.	Yes			Dry and wet precipitation.

NATURAL AND PUZZOLAN CEMENTS.

In 1917 and 1918 only one manufacturer reported an output of puzzolan or slag-lime cement, and in order that this quantity may be included in the cement totals for the United States without revealing confidential information it is added to the statistics of natural cement. The puzzolan cement plant is at Birmingham, Ala.

[1] For production of potash salts see the chapter on potash in Mineral Resources for 1918.

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The natural cement and puzzolan cement in the United States marketed during 1918 amounted to 432,966 barrels, valued at $401,341, as compared with an output of 639,456 barrels, valued at $435,370, in 1917, a decrease in 1918 of 206,490 barrels, or 32 per cent, in quantity and a decrease of $34,029, or 7.8 per cent, in value. The average price of these cements per barrel at the mills in 1918 was 92.7 cents, as compared with 68.1 cents in 1917. It is of interest to compare these prices with those of Portland cement in 1917 and 1918, which were, respectively, $1.354 and $1.596.

Natural cement was produced in 1917 in nine plants, distributed in six States—at Binnewater (near Rosendale), Jamesville, and Fayetteville, N. Y.; Siegfried, Pa.; Speeds, Ind.; Utica, Ill.; Fort Scott, Kans., and Austin and Mankato, Minn. In 1918 the plants at Fayetteville and Jamesville, N. Y., discontinued operations, and a plant at Lisbon, Ohio, resumed activity, making eight active plants in 1918.

Natural and puzzolan cement shipped, 1917 and 1918.

State.	1917			1918		
	Producing plants.	Quantity (barrels).	Value.	Producing plants.	Quantity (barrels).	Value.
Alabama[a]	1	217,761	$166,159	1	$184,066	$208,746
Illinois	1			1		
Indiana	1			1		
Kansas	1	364,066	227,816	1	193,296	149,818
Minnesota	2			2		
Ohio[b]				1		
Pennsylvania	1	57,629	41,395	1	55,604	42,777
New York	3			1		
	10	639,456	435,370	9	432,966	401,341

[a] Puzzolan only. [b] Ohio had no production in 1917.

FOREIGN TRADE IN CEMENT.

EXPORTS.

In 1918 the total quantity of hydraulic cement exported to foreign countries, including the Philippines and the Panama Canal Zone, was 2,252,446 barrels, most of it Portland cement, valued at $5,912,166 at the United States ports of shipment, or an average of approximately $2.62 a barrel, as compared with 2,586,215 barrels, valued at $5,328,536, or about $2.06 a barrel, in 1917. This represents a decrease in quantity of about 13 per cent, but an increase in value of nearly 11 per cent. The quantity exported in 1918 was about 3 per cent of the total production of hydraulic cement in that year.

The exports, as shown in the following table, go mainly to South America, which received more than 910,000 barrels, the West Indies, which received about the same quantity, and Central America, including Mexico, to which were sent more than 360,000 barrels, leaving only about 60,000 barrels for Europe, Africa, Asia, and Oceania. The export trade with the various countries fluctuates from year to year, the noteworthy increases in 1918 having been in exports to Argentina, British Guiana, Chile, and Peru, and the principal decreases in exports to Brazil, Cuba, the Dutch East Indies, Haiti, Panama, and Salvador.

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Hydraulic cement exported from the United States in 1917 and 1918.[a]

Destination.	1917		1918	
	Quantity (barrels).	Value.	Quantity (barrels).	Value.
Argentina	185,265	$362,501	223,361	$509,793
Belgian Kongo			3,825	12,139
Bermuda	8,964	17,283	3,416	9,716
Bolivia	2,397	4,989	9,095	26,035
Brazil	350,572	750,115	253,949	591,469
British East Africa				
British East Indies:				
British India	212	545	1,000	2,100
Straits Settlements			20	80
Other British			5	18
British Guiana	22,739	43,020	83,316	209,091
British Honduras	1,036	2,015	837	2,114
British Oceania:				
Australia	305	619	167	536
New Zealand			61	163
Other British	664	1,758	348	1,461
British South Africa	8	25		
British West Africa	5,756	12,978	7,070	19,781
British West Indies:				
Barbados	1,886	4,223	15,170	43,473
Jamaica	35,447	66,829	38,051	107,979
Trinidad and Tobago	45,146	83,555	35,846	94,304
Other British	19,784	41,285	13,684	38,426
Canada	9,844	24,122	10,305	32,813
Canary Islands			2,750	6,188
Chile	60,966	119,628	127,456	356,146
China	110	357		
Chosen (Korea)	364	899		
Colombia	64,579	137,545	49,339	137,174
Costa Rica	12,091	26,851	1,285	3,329
Cuba	836,739	1,740,974	643,804	1,676,299
Dominican Republic	95,775	199,224	83,626	238,117
Dutch East Indies	65,551	153,411	1,361	5,795
Dutch Guiana	5,144	10,742	3,336	9,685
Dutch West Indies	14,837	35,366	19,424	55,459
Ecuador	15,721	34,931	19,833	56,319
England	70	247		
France	510	1,096		
French Africa			935	2,714
French Guiana	2,000	3,604	1,584	4,526
French Oceania	319	813	481	1,530
French West Indies	22,966	50,382	19,675	58,423
German Oceania	161	310	10	37
Guatemala	12,259	25,448	12,859	39,848
Haiti	43,808	77,492	23,780	61,240
Honduras	9,592	23,972	6,892	20,461
Iceland and Faroe Islands			5,630	13,924
Italy	1,100	2,100	6,000	14,400
Japan	4	15	177	588
Liberia	565	1,199	300	1,250
Mexico	118,993	301,090	129,132	367,959
Miquelon, Langley, and St. Pierre Islands	191	492	180	611
Newfoundland and Labrador	9,736	19,515	13,546	36,504
Nicaragua	13,031	27,513	8,320	26,376
Norway			1,000	3,700
Panama	345,581	619,689	207,093	492,877
Paraguay	2,714	5,959	2,000	6,000
Peru	55,641	112,985	105,223	284,756
Philippine Islands	2,848	6,121	10	51
Portugal	10	40		
Portuguese Africa	1,349	3,178	183	443
Salvador	41,808	90,460	18,520	55,966
Spain	545	1,177	18	66
Turkey in Asia			250	750
Uruguay	6,072	12,537	11,338	36,983
Venezuela	27,807	54,385	22,990	65,550
Virgin Islands	4,633	10,927	2,580	8,631
	2,586,215	5,328,536	2,252,446	5,912,166

[a] Statistics compiled from records of Bureau of Foreign and Domestic Commerce, Department of Commerce.

The following table gives the quantity and value of all classes of hydraulic cement exported during the years 1900–1918, inclusive, and the proportion of exports to the total quantity of hydraulic cement manufactured in the United States. The exports at present consist almost wholly of Portland cement.

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Hydraulic cement exported from the United States, 1900–1918.[a]

Year.	Quantity (barrels).	Value.	Percentage of total quantity.	Year.	Quantity (barrels).	Value.	Percentage of total quantity.
1900	100,400	$225,306	0.6	1910	2,475,957	$3,477,981	3.2
1901	373,934	679,296	1.9	1911	3,135,409	4,632,215	3.9
1902	340,821	526,471	1.3	1912	4,215,532	6,160,341	5.1
1903	285,463	433,964	.95	1913	2,964,358	4,270,666	3.2
1904	774,940	1,104,086	2.4	1914	2,140,197	3,088,809	2.4
1905	897,686	1,387,906	2.2	1915	2,565,031	3,361,451	3.0
1906	583,299	944,886	1.1	1916	2,563,976	3,828,231	2.8
1907	900,550	1,450,841	1.7	1917	2,586,215	5,328,536	2.8
1908	846,528	1,249,229	1.6	1918	2,252,446	5,912,166	3.2
1909	1,056,922	1,417,534	1.6				

[a] Statistics compiled from records of Bureau of Foreign and Domestic Commerce, Department of Commerce.

IMPORTS.

The following table shows the quantities of foreign cement imported for consumption into the United States during the years 1878 to 1918, inclusive. The quantities given include all kinds of hydraulic cement.

The imports in 1918 were approximately 305 barrels of 380 pounds, valued at $1,200, or about $3.93 a barrel, as compared with 2,323 barrels, valued at $6,076, or about $2.62 a barrel, in 1917.

The table shows a decline in the imports of foreign cement for the six years ending with 1912, slight increases in 1913 and 1914, and large decreases since 1914, owing to the cessation of imports from Belgium, Germany, and France.

Foreign cement imported for consumption; 1878–1918, in barrels of 380 pounds.[1]

1878	92,000	1892	2,440,654	1906	2,273,493
1879	106,000	1893	2,674,149	1907	2,033,438
1880	187,000	1894	2,638,107	1908	842,121
1881	221,000	1895	2,997,395	1909	433,888
1882	370,406	1896	2,989,597	1910	306,863
1883	456,418	1897	2,090,924	1911	164,670
1884	585,768	1898	1,152,861	1912	68,503
1885	554,396	1899	2,108,388	1913	85,470
1886	915,255	1900	2,386,683	1914	120,906
1887	1,514,095	1901	939,330	1915	42,218
1888	1,835,504	1902	1,963,023	1916	1,836
1889	1,740,356	1903	2,251,969	1917	2,323
1890	1,940,186	1904	968,409	1918	305
1891	2,988,313	1905	896,845		

PORTLAND CEMENT IN CANADA.

The following statement is quoted from the preliminary report on the mineral production of Canada in 1918, issued by the Canada Department of Mines, Mines Branch, February, 1919. The statement of imports shows a smaller quantity than United States records show to have been exported to Canada from this country.

The total quantity of cement sold from Canadian cement mills in 1918 was 3,591,481 barrels, valued at $7,076,503, or an average of $1.97 a barrel, as compared with sales in 1917 of 4,768,488 barrels,

[1] Statistics compiled from records of Bureau of Foreign and Domestic Commerce, Department of Commerce.

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valued at $7,724,246, or an average of $1.62 a barrel, showing a decrease in quantity sold of 1,177,007 barrels, or 24.68 per cent, and a decrease in total value of $647,743, or 8.38 per cent.

Sales of cement from mills in Quebec in 1918 were 1,564,360 barrels, valued at $3,003,571; in Ontario 1,220,003 barrels, valued at $1,976,815; and from Manitoba, Alberta, and British Columbia 807,118 barrels, valued at $2,096,117.

The total quantity of cement made in Canada in 1918 was 3,417,660 barrels, as compared with 4,987,255 barrels made in 1917, a decrease of 1,569,595 barrels, or 31.47 per cent.

Stocks of cement on hand January 1, 1918, were 1,660,406 barrels; at the end of December they had been reduced to 1,480,565 barrels.

The total imports of cement in 1918 were 20,695 hundredweight, equivalent to 5,913 barrels of 350 pounds each, valued at $19,851, or an average of $3.36 a barrel, as compared with imports of 8,580 barrels, valued at $19,646, or an average of $2.29 a barrel in 1917.

The total consumption of cement therefore, a small export neglected, was 3,603,414 barrels, as compared with a consumption of 4,777,068 barrels in 1917, a decrease in 1918 of 1,173,654 barrels, or 24.57 per cent.

IMPORTS AND EXPORTS OF CEMENT IN FOREIGN COUNTRIES.

By Robert S. Schultz, Jr.

SOURCES OF THE DATA.

The collection of data on exports and imports of hydraulic cements was undertaken by the War Trade Board, at Washington, D. C., just prior to the signing of the armistice in November, 1918. The data were particularly desired for use in connection with post-war conditions, with special reference to probable exports to South American countries. Undertaken originally with a field limited to South America, the work was expanded after the signing of the armistice to include all data available in Washington at that time on cement imports and exports in all foreign countries. The following notes show the result of this investigation. The notes were of particular value in connection with the compilation of a world balance sheet on cements for use of the commissioners of the United States at the Peace Conference, the data from which have been rearranged into a table showing the position of the United States in the trade of the world in hydraulic cement.

War conditions resulting in the withholding of publication of the necessary data in many countries have caused these notes to be incomplete, particularly with reference to the European countries. It is felt, however, that conditions in the cement industry were so unusual during the war that figures for belligerent countries during the war period would be of less value as an indication of peace conditions than the figures for the latest obtainable normal years. The figures available are therefore given for all countries from which information was obtained.

The metric ton is used as the unit rather than the United States barrel, the metric ton being the usual unit in the countries covered. The general statistics are taken for the most part from the official

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reports of the various countries considered. Statistics of imports and exports are taken from "Foreign commerce and navigation of the United States," published by the Bureau of Foreign and Domestic Commerce, of the United States Department of Commerce.[1]

The Bureau of Foreign and Domestic Commerce issued in 1919, as Miscellaneous Series No. 79, a publication entitled "International trade in cement," which contains import statistics for countries whose imports exceeded $200,000 in value and export statistics for countries whose exports exceeded $1,000,000 in value during 1908, 1913, and also the year for which the latest figures are available. This pamphlet is sold by the Superintendent of Documents, Government Printing Office, Washington, D. C., for 10 cents a copy.

ALGERIA.

The imports of cement into Algeria amounted to 90,039 metric tons in 1913, 62,872 metric tons in 1914, and 28,362 metric tons in 1915.

ARGENTINA.

The erection of a modern Portland cement plant in Argentina is indicated by the following from Cement Era, April, 1917, page 66:

The International plans a 5,000-barrel a day plant at Sierras Bayas, which is about 200 miles from Buenos Aires, on the Trans-Andean Railroad. The plant will be erected in two units, and it is expected that the product will be used chiefly in Buenos Aires. The plant is at least a $2,000,000 enterprise.

The following note appeared in Concrete for July, 1918, page 8, cement-mill section:

Delays have occurred on construction work at Sierras Bayas, and the plant will not produce cement for six months. The town site to accommodate American employees and the crusher plant have been completed; the power plant, kilns, and coolers are 80 per cent completed, and the grinding departments are half finished; construction of the stock house is well under way. The company expects to secure an adequate coal supply from Chile.

That good progress was made during the next year is indicated by the following paragraphs from Concrete for August, 1919, page 23, cement-mill section:

According to Commerce Reports, an immense Portland cement plant is now in operation at Sierras Bayas, Argentina, the stock of which is owned entirely in the United States. The plant is located at some abandoned limekilns about 328 kilometers (203.8 miles) south of Buenos Aires. Not only does the rock contain limestone suitable for cement, but enough chips remain from the old lime works to make partly crushed material for 30 years to come. Suitable clay is also found at Sierras Bayas.

The practical difficulty in placing this cement on the market lay in the high-freight rates prevailing in Argentina, whereas cement could be shipped from New York in normal times at only $4 a ton. Satisfactory arrangements have been made, however, with the Southern Railway for a relatively low freight rate, not only in the product of the plant, but on the coal sent up from Buenos Aires as well.

The plant is most up to date in every particular, notably in its complete application of the principle of transmitting the incandescent gas as it escapes from the furnace into electric power, so that no coal is used originally in the boilers.

The present price of Portland cement in Buenos Aires is $18 to $20 gold per barrel. It is planned to fix the first price of the product of the Argentine Cement Co. at $12 gold. La Época, in a recent account of the new enterprise, predicts an ultimate output of 1,000,000 barrels annually; and, indeed, there is no country, perhaps in the world, where there is so great a demand for cement, there being no gravel to make roads, little timber for building purposes, and enormous public works in process of construction.

[1] The Geological Survey has not checked the following tables against the originals. The figures were converted to metric tons by the Survey.

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Concrete for April, 1918, contains also the following notes:

The executive board has issued a decree, in addition to the one published March 31, 1917, which authorizes an import house of this city to introduce cement manufactured in the Republic of Uruguay, in bags or sacks; that this privilege is granted to all manufacturers of Portland cement of approved brands, provided that they are imported for the construction of national works and that their condition admits of such packing, if climatic influences will not affect their storage and location.

This step was taken in consequence of a petition made by representatives of foreign Portland cement manufacturers of well-known and approved brands, and as the council of public works has not found any technical objections which should be contrary to the privilege granted to Uruguayan cement, such privilege is to be also granted to all other brands of cement imported from foreign countries.

Cement exported from the United States to Argentina, fiscal years ending June 30, 1912–1918.

Year.	Quantity (metric tons).	Value.	Year.	Quantity (metric tons).	Value.
1912	342	$2,302	1916	10,689	$82,012
1913	11,981	84,689	1917	18,645	200,481
1914	8,171	62,787	1918	32,690	402,442
1915	28,375	218,042			

Cement imported into Argentina, 1911–1918, metric tons.

Country.	1911	1912	1913	1914	1915	1916	1917	1918
Belgium	164,648	177,381	396,690	170,034	6,394	.....	.....	318
Austria-Hungary	4,340	4,622	10,845	8,422	(a)	(a)	(a)	(a)
Denmark	784	.....	13,907	9,071	(a)	(a)	(a)	(a)
France	83,785	74,639	100,519	56,018	23,380	20,252	5,128	804
Germany	44,097	25,591	54,378	42,351	3,836	.....	.....	.....
Spain	2,872	.....	3,265	2,204	.....	.....	.....	.....
Sweden	25,107	15,170	43,800	10,152	.....	.....	.....	.....
United Kingdom	77,708	63,500	114,009	39,459	83,272	60,559	83,744	12,483
United States	513	.....	11,548	10,714	21,695	7,510	24,304	36,143
Other countries	5,815	781	10,265	4,802	a 98,724	a 84,522	16,504	6,744
	409,669	361,684	759,226	353,227	237,301	172,843	79,680	56,492

a Includes Scandinavian countries and Austria-Hungary.

AUSTRALIA.

Cement exported from the United States to Australia, fiscal years ending June 30, 1912–1918.

Year.	Quantity (metric tons).	Value.	Year.	Quantity (metric tons).	Value.
1912	517	$5,130	1916	186	$3,831
1913	573	6,751	1917	52	595
1914	292	5,904	1918	4	54
1915	177	3,140			

Cement imported into Australia, 1901–1917, in metric tons.

1901	72,275	1910	81,894
1902	54,587	1911	84,847
1903	48,497	1912	131,282
1904	28,512	1913	127,607
1905	35,574	1914 [1]	52,860
1906	40,334	1914–15	71,486
1907	29,127	1915–16	77,060
1908	46,486	1916–17	7,623
1909	43,098		

[1] Six months ended June 30, 1914, when change was made from calendar to fiscal year.

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Cement imported into Australia, 1912–1917, in metric tons.

Country.	1912	1913	1914–15 [a]	1915–16	1916–17
United Kingdom	39,101	32,458	36,310	25,211	1,891
Canada	.....	.....	.....	109	.....
Hongkong	26	.....	2,041	5,773	1,396
India	.....	.....	.....	31	.....
New Zealand	3,958	2,838	11,953	7,067	2,029
Austria	161	917	417	.....	.....
Belgium	12,705	8,409	882	.....	128
China	51	.....	929	5,334	536
Denmark	1,417	5,707	1,888	14,587	767
Java	7	.....	.....	.....	.....
Sumatra	189	65	.....	.....	.....
Germany	70,792	73,214	14,810	216	306
Netherlands	1,119	18	.....	20	.....
Norway	1,049	3,022	1,175	3,846	85
Sweden	281	490	109	450	.....
United States	386	396	78	257	37
Japan	.....	25	866	14,131	448
Other countries	40	48	28	28	.....
	131,282	127,607	71,486	77,060	7,623

[a] Half a year is lacking on account of change to fiscal year.

AUSTRIA.[1]

The Austrian cement industry has been paralyzed by the war. None of the big companies paid any dividends last year, and the output was less than 45 per cent of the normal.

BANGKOK.

Cement imported into Bangkok, 1916–1918, in metric tons.

Country.	1916–17	1917–18	Country.	1916–17	1917–18
Singapore	0.1	1.4	Japan	.....	10.5
Hongkong	340.2	25.4	Indo-China	7,042.1	8,813.2
United Kingdom	40.4	50.3		7,787.0	8,900.8
India	1.3	.....			
Denmark	362.9	.....			

BELGIUM.

Cement imported into Belgium for consumption, 1907–1913, in metric tons.

Country.	1907	1908	1909	1910	1911	1912	1913
Germany	26,495.1	3,548.9	7,782.0	10,727.2	23,872.4	15,928.4	13,835.9
France	5,993.3	2,509.5	1,516.2	2,101.0	2,067.3	3,893.4	3,001.6
Luxemburg	420.0	593.3	362.6	265.5	864.8	6,901.1	2,312.6
Great Britain	442.6	773.8	209.5	243.6	.....	551.5	2,209.4
Hamburg	1,393.8	.....	.....	.....	.....	.....	106.8
Netherlands	2,672.6	1,377.6	593.3	934.9	913.3	1,287.4	2,011.0
Denmark	.....	.....	.....	.....	.....	28.1	2,071.5
Other countries	43.4	119.3	106.1	61.9	630.9	228.0	60.3
	37,460.8	8,922.4	10,569.7	14,334.1	28,348.7	28,817.9	25,609.1

[1] Mineral Industry, 1916.

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Cement exported from Belgium, 1907-1913, in metric tons.

Country.	1907	1908	1909	1910	1911	1912	1913
Belgian Kongo		1,785.8	2,935.8	3,074.1	6,551.0	8,072.6	10,143.3
Germany	102,753.0	95,629.2	112,620.5	99,599.5	81,943.5	87,988.4	38,995.7
Argentina	87,685.5	82,559.8	110,315.4	145,155.3	168,575.1	178,375.8	221,063.4
Australia (except New Zealand)	2,004.0	5,350.7	4,593.8	9,485.9	12,637.7	21,468.4	10,370.8
Brazil	34,407.1	34,228.2	33,501.1	50,772.3	45,065.5	67,826.7	54,553.6
Chile	33,455.3	10,366.1	14,815.6	13,052.6	19,689.8	18,191.1	17,907.5
French West Africa		1,037.8			1,634.5	3,560.9	2,058.3
Portuguese West Africa		2,125.4			1,539.2	2,620.1	2,163.2
Portuguese East Africa			1,589.5	1,599.5			
Cuba	12,124.2	4,372.4	3,941.6	3,423.2	3,752.7	2,984.7	2,628.9
Egypt	32,681.4	24,377.5	24,682.4	26,857.8	41,071.5	42,723.7	23,800.9
Spain	14,303.0	17,016.5	19,208.7	24,661.6	22,841.1	16,334.2	19,841.0
United States	81,137.5	22,897.5	21,248.5	15,398.3	2,047.9	1,460.8	
France	9,808.5	13,422.4	24,961.5	25,062.0	47,400.1	50,289.1	45,990.1
Luxemburg	4,095.6	4,042.7	4,709.0	7,493.7	9,370.4	27,097.4	19,671.4
Great Britain	88,917.7	75,455.7	57,921.3	50,354.5	64,547.2	90,932.7	87,747.9
British India	7,845.8	7,614.0	6,964.2	6,923.8	5,484.2	13,819.3	8,172.8
Dutch East Indies	5,263.3	5,598.6	6,956.9	9,651.4	13,421.2	20,909.0	25,738.9
English Indo-China	3,140.2	1,074.0			1,693.1		
Ireland	12,786.6	8,089.6	4,422.3	3,875.6	2,084.0	3,793.3	3,107.4
Morocco			868.8	2,526.1	4,544.0	13,390.3	42,791.3
Mexico	11,410.6	7,191.7	11,632.1	6,514.1	5,511.2	4,018.6	2,114.2
Netherlands	88,895.1	89,297.9	125,214.4	130,545.0	162,859.4	179,968.5	179,128.9
Norway	3,365.2	4,199.1	1,772.6				
Peru	7,230.4	3,551.1	3,013.7	4,949.7	4,308.7	7,654.4	6,026.3
Portugal	13,074.7	12,393.3	14,713.2	18,095.5	17,990.6	17,131.1	16,309.4
Russia	8,905.7	3,455.6	1,428.4	1,012.6	9,752.8	15,457.8	
Sweden		1,916.9	1,753.0	1,939.5	2,558.0		
Turkey	6,226.3	3,046.4	9,294.7	17,641.5	28,453.4	17,245.1	5,405.4
South African Customs Union					16,339.0	20,687.5	12,971.2
Uruguay	6,099.1	3,157.4	5,814.4	6,039.1	9,600.9	10,693.3	5,682.8
Bulgaria		794.8	1,536.2		1,130.9		
Canada	11,192.9	6,073.9	2,055.3	1,866.4	1,658.8		
China	4,959.0	2,460.4	568.8	1,793.0	205.9		2,008.2
Colombia		901.9	1,454.3	817.5	1,021.2		
Cape Colony	2,663.4	4,312.0	2,708.4	7,053.0			
Other countries	30,601.2	13,861.0	15,268.4	17,937.1	11,700.2	25,337.8	20,458.9
	727,122.3	573,757.3	654,504.8	715,171.2	828,934.7	970,032.6	886,851.7

BOLIVIA.

Cement exported from the United States to Bolivia, fiscal years ending June 30, 1913–1918.

Year.	Quantity (metric tons).	Value.	Year.	Quantity (metric tons).	Value.
1913	655	$6,923	1916	460	$3,799
1914	394	3,512	1917	211	1,781
1915	43	334	1918	611	7,388

Cement imported into Bolivia, 1912-1914, in metric tons.

Country.	1912	1913	1914
Germany	4,252.4	4,281.3	1,795.6
Great Britain	1,055.9	3,602.7	86.5
Chile	6.6	892.0	310.8
United States	53.5	580.7	108.9
Peru	210.1	352.6	361.8
Belgium	31.1	201.3	70.9
Brazil	17.7	38.6	14.1
Argentina	50.4	16.1	94.0
France	1.6	1.2	4.5
Uruguay		.7	
Italy	45.3		
Spain	25.8		
	5,750.4	9,967.2	2,847.1

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BRAZIL.

The Cement Era reported in its issue of November, 1917, page 51, that

A cement-manufacturing plant is under construction at Bello Horizonte, the capital city of the State of Minas Geraes, Brazil, to be operated by Macchiorlatti & Co. This firm claims to have invented a wood-burning oven capable of containing 2,000 calories of heat without consuming large amounts of fuel. It is reported that the plant will soon be in operation.

Cement exported from United States to Brazil, fiscal years ending June 30, 1912–1918.

Year.	Quantity (metric tons).	Value.	Year.	Quantity (metric tons).	Value.
1912	3,811	$27,450	1916	56,844	$393,238
1913	59,998	398,116	1917	46,601	426,166
1914	27,962	200,337	1918	74,524	954,137
1915	57,122	412,375			

Cement imported into Brazil, 1910–1914, in metric tons.

Country.	1910	1911	1912	1913	1914
Germany	101,610.4	120,154.7	174,029.0	188,806.4	78,442.4
Argentina	340.0	80.3	289.8	155.1	145.5
Austria-Hungary	1,377.7	1,029.1	5,291.8	10,323.1	4,538.2
Belgium	47,263.1	49,042.9	70,894.8	60,215.9	16,823.2
Denmark	1,891.0	4,957.5	8,632.1	7,317.0	12,120.0
United States	435.5	2,147.5	19,240.8	50,623.6	24,997.8
France	9,005.0	9,228.9	6,501.8	9,743.0	1,613.7
Great Britain	100,449.0	87,691.2	79,403.0	130,367.3	39,347.2
Spain	1,395.0	.....	11.8	.....	.....
Italy	20.6	24.8	94.6	556.0	34.2
Norway	.....	.....	255.0	.....	.....
Paraguay	.....	17.0	.....	.....	.....
Portugal	3.0	.....	.....	9.0	19.6
Canada	.....	.....	551.5	.....	.....
British India	.....	.....	2.5	.....	.....
Sweden	181.3	175.1	510.0	4,560.0	1,479.5
Switzerland	19.0	.8	.2	.....	.....
Turkey in Asia	.....	.026	.....	.....	.....
Uruguay	180.0	139.1	1,292.4	2,096.6	1,161.6
Other countries	.....	.1	30.4	.....	.....
	264,170.6	274,689.026	367,031.5	464,773.0	180,722.9

BRITISH GUIANA.

Cement exported from the United States to British Guiana, 1912–1918.

Year.	Quantity (metric tons).	Value.	Year.	Quantity (metric tons).	Value.
1912	914	$6,780	1916	2,941	$24,293
1913	1,240	10,068	1917	3,835	36,293
1914	621	5,617	1918	7,393	101,219
1915	2,133	15,711			

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Cement imported into British Guiana, 1911–1916, in metric tons.

Country.	1911	1912	1913	1914	1915	1916
United Kingdom	947	842	1,815	2,390	1,355	2,472
United States	.....	.....	1,179	780	2,976	3,356
Germany	.....	.....	1	.....	.....	.....
Belgium	.....	.....	56	.....	.....	.....
Denmark	.....	.....	264	113	57	.....
Holland	.....	.....	10	.....	.....	.....
	1,930	2,119	3,325	3,283	4,388	5,828

Cement reexported (transshipped) from British Guiana, 1911–1916, in metric tons.

Country.	1911	1912	1913	1914	1915	1916
From—						
United Kingdom	.....	.....	19	66	1	.....
Denmark	.....	.....	235	206	109	.....
United States	.....	.....	.....	2	2	1
To—						
Dutch Guiana	.....	.....	254	272	110	.....
French Guiana	.....	.....	.....	2	2	.....
British West Indies	.....	.....	.....	.....	.....	1
	295	194	254	274	112	1

Cement (not native product) exported from British Guiana, 1913–1916, in metric tons.

Country.	1913	1914	1915	1916
Dutch Guiana	43	9	54	77
French Guiana	.....	.....	2	.....
British West Indies	.....	.....	0.2	.....

BRITISH INDIA.

Cement imported into British India, years ending March 31, 1908–1917, in metric tons.

Country.	1908–09	1909–10	1910–11	1911–12	1912–13	1913–14	1914–15	1915–16	1916–17
United Kingdom	85,140	84,784	111,886	102,346	[a]29,832 125,518	[a]28,989 123,853	[a]21,085 125,972	[a]11,018 87,828	[a]8,286 15,469
Austria-Hungary	1,382	1,188	1,697	1,938	2,670	1,527	1,284	.....	.....
Belgium	9,490	10,957	10,458	4,086	12,782	3,381	3,697	345	.....
Germany	1,168	1,455	1,387	5,250	16,394	16,488	4,281	216	4
Italy	162	90	829	1,828	2,821	1,147	1,848	988	.....
China (Hongkong)	1,429	3,158	2,164	2,892	1,916	1,021	4,795	9,121	2,224
Japan	.....	.....	.....	0.2	18	100	4,787	32,460	17,443
France	894	394	108	.....	.....	.....	.....	.....	.....
Ceylon	95	107	89	.....	.....	.....	.....	.....	199
Straits Settlements	38	60	58	.....	.....	.....	.....	.....	7
United States	.....	.....	.....	.....	.....	.....	.....	.....	128
Other countries	13	34	7	490	1,022	1,355	636	2,780	12
	99,811	102,227	128,683	118,830.2	192,973	177,861	168,385	144,756	43,772

[a] Government imports.

Exports have been negligible, the maximum having been 304 hundredweight in 1910–1911.

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Cement exported from the United States to British India, fiscal years ending June 30, 1913–1918.

Year.	Quantity (metric tons).	Value.	Year.	Quantity (metric tons).	Value.
1913	311	$1,949	1916	29	$351
1914	608	3,840	1917	101	1,010
1915	36	557	1918	176	2,155

CHILE.

Cement exported from the United States to Chile, fiscal years ending June 30, 1912–1918.

Year.	Quantity (metric tons).	Value.	Year.	Quantity (metric tons).	Value.
1912	4,447	$35,902	1916	11,595	$93,440
1913	6,627	51,823	1917	11,723	112,397
1914	4,517	35,807	1918	12,017	158,731
1915	9,701	73,976			

COLOMBIA.

Cement exported from the United States to Colombia, fiscal years ending June 30, 1912–1918.

Year.	Quantity (metric tons).	Value.	Year.	Quantity (metric tons).	Value.
1912	7,254	$54,048	1916	11,253	$87,689
1913	10,066	85,801	1917	11,036	122,277
1914	16,055	126,333	1918	8,613	122,236
1915	8,990	69,292			

Hydraulic and Roman cement imported into Colombia, 1915–16, in metric tons.

Country.	1915	1916	Country.	1915	1916
Dutch Antilles	62.0	.....	Italy	28.5	.....
Spain	4.2	.....	Panama	180.4	.....
United States	7,193.9	.....	Other countries	170.4	.....
France	2.4	.....		8,296.1	12,798.6
Great Britain	654.3	.....			

COSTA RICA.

Cement exported from the United States to Costa Rica, fiscal years ending June 30, 1912–1918.

Year.	Quantity (metric tons).	Value.	Year.	Quantity (metric tons).	Value.
1912	1,698	$15,206	1916	2,582	$23,420
1913	2,018	17,658	1917	2,580	29,999
1914	2,337	23,389	1918	1,147	15,382
1915	3,187	26,897			

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Cement imported into Costa Rica, 1912–1916, in metric tons.

Country.	1912	1913	1914	1915	1916
United States	1,571.6	2,645.4	2,319.4	3,369.8	2,750.7
Germany	3,711.2	3,156.1	1,828.4	.....	.....
France	159.6	91.3	54.0	.....	1.1
United Kingdom	156.9	316.0	175.9	.....	.....
Belgium	718.9	612.1	758.6	0.1	.....
Panama	.....	4.1	88.3	919.3	6.2
Sweden	.....	.....	.....	90.0	.....
Spain	2.2	.....	.....	.....	10.1
Italy	2.7	.....	.....	.....	.....
Denmark	.....	.....	.....	.....	360.0
Other countries	.....	.....	.....	0.1	.....
	5,623.1	6,825.0	5,224.6	4,379.3	3,128.1

CUBA.

Concrete for February, 1918, page 22, cement-mill section, says:

The manufacture of cement in Cuba is no new thing, the Almendares works originally started by French capital and subsequently refinanced by Cuban interests, with American engineering talent, has been in operation for many years. But, owing to the limited production, it has not interfered materially with the imports of American cement into the island of late years. American cement has been imported to the extent of 1,000,000 barrels (170,000 metric tons) and more a year, and trade has been constantly growing.

The same journal, in the issue of May, 1918, notes that

The Cuban Portland Cement Co. has entered the earning stage. The first large sale, 2,000 barrels, has been closed. A monthly production of 50,000 barrels is expected.

Five months later the Engineering and Cement World, October 15, 1918, page 56, stated that the

demand for cement has been so great that the Cuban Portland Cement Corp. will doubtless take action to increase the crushing capacity so that 2,000 instead of the present capacity of 1,000 barrels a day can be produced. A cablegram from the general manager is as follows: "Most important to increase production. 1,000 barrels (170 metric tons) a day not sufficient. Will clean out mill stock of cement in few days. Growing demand and general outlook justified expectations steady increase to reach 2,000 barrels (340 metric tons) November or sooner. Trade reports on quality very good.

Cement exported from the United States to Cuba, fiscal years ending June 30, 1912–1918.

Year.	Quantity (metric tons).	Value.	Year.	Quantity (metric tons).	Value.
1912	93,412	$722,537	1916	143,854	$1,179,435
1913	120,118	942,608	1917	124,964	1,282,818
1914	125,667	1,011,720	1918	147,849	2,006,065
1915	93,418	748,754			

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Cement imported into Cuba, 1911–1917, in metric tons.

Country.	1911	1912	1913	1914	1915	1916	1917 (first half).
United States	155,592	194,494	259,449	220,836	183,426	256,140	98,349
Germany	653	117	621	16	.....	.....	.....
Belgium	8,075	4,460	4,109	1,609	.....	.....	.....
Spain	55	4	7	.....	215	128	3
France	7,537	8,603	8,859	7,900	3,201	3,481	656
Holland	147	.....	.....	.....	.....	.....	.....
Italy	.....	33	3	5	.....	.....	.....
United Kingdom	123	.....	1,065	323	.....	83	.....
Austria	.....	.....	.....	114	.....	.....	.....
Canary Islands	.....	.....	.....	4	.....	.....	.....
	172,182	207,711	274,113	230,807	186,842	259,832	99,008

DENMARK.

With regard to the Danish cement industry, Concrete for October, 1917, page 31, cement mill-section, says:

According to the Commerce Reports, one of the important interests affected by the coal shortage in Denmark is the manufacture of cement. These works are now closing down and this will cause disturbance in the building trades, which are already hampered by the shortage and high price of materials and labor. * * * Denmark began the manufacture of cement in 1897 with a production of 459,000 barrels [78,070 metric tons]. In that year the net import was 459,000 barrels and the consumption 590,900 barrels. In 1913 the production was 2,965,000 barrels [504,340 metric tons] and the consumption 1,622,000 barrels. The amount of coal annually required in the Danish cement industry is about 200,000 tons.

About a year later the same journal stated [1] that

the production of Portland cement in Denmark in normal times amounted to about 2,730,000 barrels, each of 375 pounds net [about 464,370 metric tons], of which about 1,000,000 barrels [170,000 metric tons] were used in Denmark and the remainder was exported. During the war, the production has been greatly reduced on account of lack of fuel, and during 1917 a majority of the plants were closed for this reason. For the past 18 months the production has not been sufficient to meet the demands of the domestic market.

Cement imported into Denmark, 1910–1913, in metric tons.

Country.	1910	1911	1912	1913
Tyskland	11,299.1	11,212.1	12,402.2	14,367.2
Norway	3,518.3	3,338.5	2,314.5	1,635.9
Sweden	15,429.4	7,952.2	10,946.6	5,381.8
Belgium	.....	.....	342.8	11.1
Other countries	211.0	189.3	62.8	85.3
	30,457.8	22,692.1	26,068.9	21,481.3

Cement reexported from Denmark, 1910–1913, in metric tons.

Country.	1910	1911	1912	1913
Faroe Islands	18.5	17.6	4.3	0.4
Iceland	.....	16.7	80.0	44.0
Russia	.....	756.5	.....	.....
Finland	.....	294.4	.....	.....
Other countries	7.4	0.3	2.8	0.2
	25.9	1,085.5	87.1	44.6

[1] Concrete, September, 1918, p. 31, cement-mill section.

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Portland cement exported from Denmark, 1910–1913, in metric tons.

Country.	1910	1911	1912	1913
Germany	21,028.0	19,829.4	19,707.7	18,077.5
Great Britain	2,165.5	2,568.1	3,270.0	3,096.0
Norway	8,392.4	7,749.7	7,745.1	9,847.1
Sweden	2,820.7	4,743.1	4,440.5	3,665.0
Finland	24,636.7	40,177.7	47,689.8	60,758.6
Russia	13,081.2	42,651.7	37,090.8	57,962.0
West Indies, other than Danish	----------	3,967.9	6,703.8	6,049.2
Brazil	714.6	6,207.1	6,782.8	10,858.5
Argentina	1,253.0	6,579.1	7,423.0	15,904.6
Rest of South America	1,877.9	226.3	1,629.4	1,689.7
British South Africa	6,240.6	7,347.3	11,095.1	7,918.0
Siam	8,109.5	16,222.1	16,899.8	26,828.6
China	689.0	1,137.6	87.2	1,598.5
Eastern Asia	----------	----------	4,810.3	4,660.0
Asia, other than eastern	----------	----------	3,315.0	1,037.0
Australia	----------	----------	3,421.0	3,795.8
Faroe Islands	----------	72.2	147.9	207.5
Iceland	1,566.8	2,994.0	3,871.6	4,032.3
Danish West Indies	1,805.1	1,156.2	421.0	616.9
Mexico	344.9	----------	----------	----------
Dutch East Indies	513.7	----------	----------	----------
Other countries	972.8	848.9	1,000.1	976.5
	96,232.4	164,508.4	187,551.9	239,509.3

DOMINICAN REPUBLIC.

Cement exported from the United States to the Dominican Republic, fiscal years ending June 30, 1912–1918.

Year.	Quantity (metric tons).	Value.	Year.	Quantity (metric tons).	Value.
1912	5,968	$44,980	1916	10,866	$88,492
1913	8,935	71,361	1917	13,938	146,129
1914	9,931	77,733	1918	17,211	244,354
1915	7,246	56,817			

DUTCH EAST INDIES.

Cement exported from the United States to the Dutch East Indies, fiscal years ending June 30, 1912–1918.

Year.	Quantity (metric tons).	Value.	Year.	Quantity (metric tons).	Value.
1912	55	$429	1916	475	$4,850
1913	52	350	1917	5,807	76,309
1914	----------	----------	1918	6,297	87,820
1915	67	649			

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Cement imported into the Dutch East Indies, 1912–1915, in metric tons.

Country.	1912	1913	1914	1915
Holland	57,175	67,735	41,417	71,563
Great Britain	9,066	5,796	6,065	2,314
Germany	18,547	39,475	22,309	6,902
Belgium	16,162	21,267	7,996	207
Italy	.....	.....	39	58
Austria	.....	.....	561	254
Denmark	.....	.....	.....	692
British India	.....	821	46	77
Penang	2,204	1,503	1,704	999
Malacca	.....	.....	.....	91
Singapore	3,831	3,125	3,162	2,896
Hongkong	859	.....	575	3,690
China	.....	.....	537	1,313
Japan	.....	.....	5,714	22,511
United States	.....	.....	84	75
Indo-China	.....	.....	3,719	.....
France	703	.....	186	10,182
Other countries	461	1,121	681	233
	109,008	140,843	94,795	124,057

Cement exported from the Dutch East Indies, 1912–1915.

	Metric tons.		Metric tons.
1912	1,413	1914	757
1913	1,558	1915	586

DUTCH WEST INDIES.

Cement exported from the United States to the Dutch West Indies, fiscal years ending June 30, 1912–1918.

Year.	Quantity (metric tons).	Value.	Year.	Quantity (metric tons).	Value.
1912	100	$836	1916	2,241	$19,626
1913	698	5,152	1917	3,752	46,337
1914	494	4,704	1918	3,148	48,318
1915	787	6,928			

DUTCH GUIANA.

Cement exported from the United States to Dutch Guiana, fiscal years ending June 30, 1912–1918.

Year.	Quantity (metric tons).	Value.	Year.	Quantity (metric tons).	Value.
1912	2	$12	1916	1,502	$13,024
1913	.....	.....	1917	833	8,225
1914	.....	.....	1918	614	7,928
1915	86	681			

ECUADOR.

Cement exported from the United States to Ecuador, fiscal years ending June 30, 1912–1918.

Year.	Quantity (metric tons).	Value.	Year.	Quantity (metric tons).	Value.
1912	481	$4,317	1916	4,787	$39,523
1913	1,975	13,184	1917	6,029	59,790
1914	1,392	9,198	1918	3,184	47,344
1915	2,914	23,791			

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Cement imported into Ecuador, 1910–11, in metric tons.

Country.	1910	1911
Germany	2,699.9	2,059.4
United States	173.5	257.8
Belgium	694.4	344.6
Italy	51.2	10.0
Peru	63.3	.....
Great Britain	.....	1.4
France	.....	.1
	3,682.3	2,673.3

EGYPT.

Cement imported into Egypt, 1911–1916, in metric tons.

Country.	1911	1912	1913	1914	1915	1916
England	35,142	27,980	13,743	7,698	897	1,194
Germany	1,986	2,843	1,564	1,283	.....	3
Austria-Hungary	10,663	18,409	9,772	9,003	.....	.....
Belgium	50,297	46,259	24,776	20,622	722	.....
Denmark	19	204	11	.....	.....	.....
France	8,218	8,356	7,174	5,073	2,744	977
Greece	68	.....	50	397	4,111	.....
Holland	182	18	.....	.....	.....	.....
Italy	96	91	1,170	4,065	8,410	14,956
Rumania	.....	.....	50	.....	.....	.....
Sweden	.....	.....	222	235	.....	.....
United States	.....	.....	.....	.....	.....	18
Other countries	.....	.....	.....	.....	1,352	.....
	106,670	104,160	58,532	48,376	18,236	17,148

Cement reexported from Egypt, 1913–1916, in metric tons.

Country.	1913	1914	1915	1916
British possessions on Mediterranean	11.3	46	10	2
Tripoli	25.0	49	.....	.....
Turkey	109.5	22	.....	.....
Greece	.....	.....	40	.....
Massana	.....	.....	.....	10
Rhodes	.....	.....	.....	4
	145.8	117	50	16

EUROPE.

Writing in Concrete,[1] L. W. Schmidt says of Europe in general:

It is expected that France, Belgium, Germany, and Austria will be capable of supplying the cement needed for rebuilding by their own factories. These countries, however, have gone through many years of war, and the cement industry in all of them has suffered very much. It is known that none of the Belgium cement works is working for private supplies, and that the German cement works have curtailed very largely the output available for building purposes. In France, nearly all of the cement made is manufactured for governmental orders. When the war is ended, it will show that none of the cement works in that part of Europe will be able at once to return to its pre-war capacity. It is very doubtful if they will be able to do so for a long time to come.

Europe has lost 9,000,000 men killed in war. It is estimated that this will reduce the industrial efficiency of Europe at the rate of 8 per cent, which will affect the cement industry.

Corresponding with an increase in the consumption of cement there is likely to be a decrease in production. This decrease may amount to as much as 15 per cent of the pre-war production in the European countries.

[1] Concrete, June, 1918, p. 58, cement-mill section.

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FRENCH AFRICA.

Cement imported into French Africa, 1912–1914, in metric tons.

[Upper figures from France].

Country.	1912	1913	1914
Senegal	7,885.7	6,875.4	6,278.7
	53.3	52.9	72.2
Nigeria, Upper Senegal	410.3	404.3	1,111.8
	.....	.....	.....
French Guinea	2,463.7	1,256.8	1,045.5
	114.2	12.2	165.7
Ivory coast	1,232.4	987.6	972.8
	1,139.2	1,590.1	1,006.7
Dahomey	290.0	490.9	1,622.2
	3,111.4	2,184.9	1,007.7
Gabon	406.9	365.3	150.8
	211.5	461.6	343.7
Kongo	307.2	257.1	495.0
	586.6	686.0	134.2
Reunion	.....	1,939.3	275.3
	.2	118.0	.....
Madagascar	6,857.4	4,637.8	5,524.3
	281.4	139.4	326.6
Somali coast	303.0	409.4	22.9
	581.4	187.7	317.6

FRENCH COLONIES IN INDIA.

Cement imported into French India, 1912 and 1914, in metric tons.

Country.	1912	1914
France	41.0	194.0
English colonies	7.5	14.0

FRENCH GUIANA.

Cement exported from United States to French Guiana, fiscal years ending June 30, 1912–1918.

Year.	Quantity (metric tons).	Value.	Year.	Quantity (metric tons).	Value.
1912	4	$35	1916	159	$1,344
1913	2	18	1917	226	2,125
1914	4	34	1918	308	3,835
1915	88	668			

Cement imported into French Guiana, 1912 and 1914, in metric tons.

Country.	1912	1914
France	360.1	425.6
English colonies	.2	1.7
United States	2.8	.....
Dutch Guiana	3.4	.....
	366.5	427.3

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FRENCH INDO-CHINA.

According to R. W. Lesley [1] the employment of French capital in the establishment of works in Indo-China has been going on for some years, and the leading factory at Haifong produced during 1915 about 72,000 metric tons of cement and hydraulic lime, valued at about $1,200,000—an increase of about 35 per cent in quantity and about 50 per cent in market value over the output of 1914.

Cement imported into Indo-China, 1912 and 1914, in metric tons.

Country.	1912	1914	Country.	1912	1914
France	10,877.7	7,527.3	Singapore	0.5	.....
China	4.6	6.4	England	100.4	49.8
Japan	90.0	.....	Germany	.6	4.1
Siam	20.8	.....		11,558.8	7,682.2
Hongkong	464.2	94.6			

Cement exported from Indo-China, 1912 and 1914, in metric tons.

Country.	1912	1914	Country.	1912	1914
China	5,665.1	3,824.4	Dutch East Indies	.....	5,060.0
Siam	8,928.5	4,232.0	Singapore	.....	3,689.2
Philippines	6,574.6	968.8		39,538.1	30,688.7
Hongkong	18,369.9	11,718.3			
Japan	.....	1,196.0			

FRENCH OCEANIA.

Cement imported into French Oceania, 1912 and 1914, in metric tons.

Country.	1912	1914
France	193.4	386.1
England	.....	1.8
Australasia	127.0	118.4
United States	11.5	.....
	331.9	506.3

1.1 tons reexported in 1912—0.7 ton to United States and 0.4 ton to other countries.

FRENCH WEST INDIES.

Cement exported from the United States to French West Indies, fiscal years ending June 30, 1912–1918.

Year.	Quantity (metric tons).	Value.	Year.	Quantity (metric tons).	Value.
1912	115	$966	1916	2,090	$18,132
1913	1,113	9,470	1917	2,935	31,140
1914	792	7,167	1918	2,922	44,595
1915	1,035	9,395			

[1] Lesley, R. W., address before Portland Cement Association, Dec. 14, 1916.

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GERMANY.

But little is known of the production of German Portland cement during the year 1916. The war conditions have largely stopped construction, but large quantities of cement have been used in the trenches. The Silesian Portland Cement Co. has advanced its prices and attempts have been made to make cartell agreements with the Rhenish-Westphalian and Central Groups of German manufacturers.[1]

The report for 1917 of the Rhenish-Westphalian Cement Syndicate states that during that year it was several times necessary to raise prices in order to keep pace with the continually increasing cost of production. The results for the year were more favorable than those for 1916, chiefly owing to the greater army demand. On the other hand, the factories were adversely affected by deterioration in the quality of the oils, fats, coals, and other materials required for their working. They suffered still more from the fact that often repairs could not be effected adequately or at the right time because of a lack of labor, while spare parts were in many cases unprocurable. The greater wear and tear to which the factories were subjected made it necessary to write off large amounts and to lay aside greater reserves for renewals. It is questionable, however, whether the deterioration of plant and material can be made good by money reserves, and in any case unwelcome consequences are bound to follow.

The interests of the industry also demand that any taxation imposed on cement production shall fall equally on competing building materials, and that protection should be afforded against the foundation of new and unnecessary concerns and against the competition of foreign products. Attention should be paid to this last point in the conclusion of commercial agreements.[2]

GUADELOUPE.

Cement imported into Guadeloupe, 1915–1917.

Country.	1915		1916		1917	
	Quantity (metric tons).	Value.	Quantity (metric tons).	Value.	Quantity (metric tons).	Value.
United States	219	$3,710	223	$9,041	1,231	$74,198
All countries	321	5,282	257	9,717	1,450	83,963

No exports or production.

GUATEMALA.

Cement exported from United States to Guatemala, fiscal years ending June 30, 1912–1918.

Year.	Quantity (metric tons).	Value.	Year.	Quantity (metric tons).	Value.
1912	1,681	$19,137	1916	3,207	$27,037
1913	3,149	25,244	1917	3,477	27,963
1914	2,148	19,122	1918	1,680	23,808
1915	1,813	14,127			

In addition to the cement from the United States about 3 metric tons was imported from England into Guatemala in 1916.

The following extract is from Cement Era, issue of May, 1917, page 69:

Consul Samuel C. Reat, at Guatemala City, sends details of the incorporation of a plant to manufacture Portland cement in Guatemala. The company is incorporated

[1] Mineral Industry, 1916. [2] Concrete, November, 1918, p. 55, cement-mill section.

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for $250,000 and expects to employ 150 to 200 men. The company in 1914 applied to the Guatemalan Government for a concession for the exclusive privilege of manufacturing Portland cement in this country. The exclusive clause of the franchise aroused opposition and caused a protest to be filed. Later this feature was withdrawn from the application and the concession was granted in 1914 for a term of 10 years. The same year work on the company's plant, located on the road to Chinautla, 1 mile from Guatemala City, was begun and has just been completed.

To provide the necessary transportation facilities the company has built 2 miles of railroad leading from the plant to a connection with the yards and terminals of the International Railways of Central America at Las Vacas.

The company owns at the site of the plant 400 acres of land, including what is said to be a practically inexhaustible supply of limestone, together with deposits of clay and volcanic ash, which supply the elements necessary for the manufacture of cement. Except the small contracts for machinery, which were awarded in Germany prior to the European war, the company has imported all its machinery, valued at more than $50,000, from the United States. The main plant is housed in a building of wood and is known as the dry system, with rotary kilns, and has facilities for the use of oil as fuel. The plant has been constructed in sections or units, and the capacity will vary from 50,000 to 100,000 barrels of cement per annum [8,500 to 17,000 metric tons].

On account of the high steamship and railway transportation charges, cement that costs $1.80 to $2.25 a barrel in the United States is sold in Guatemala City at $7 to $7.25 a barrel. The carrying charge on cement from New York City to Puerto Barrios, formerly $0.80 a barrel, has increased since the European war to $1.50. It costs $2.60 United States gold to haul a barrel of cement from Puerto Barrios to Guatemala City, and there is an additional charge of $0.60 per barrel for unloading from steamer and loading on train at Puerto Barrios. In view of these conditions local dealers state that when the plant of the new company begins operations it will be practically impossible for American or other foreign manufacturers to meet the local competition, and that Guatamala will probably cease importing cement altogether.

HAITI.

Cement exported from the United States to Haiti, fiscal years ending June 30, 1913–1918.

Year.	Quantity (metric tons).	Value.	Year.	Quantity (metric tons).	Value.
1912	3,997	$30,248	1916	5,728	$46,565
1913	5,668	43,336	1917	7,004	63,185
1914	3,249	25,574	1918	7,153	83,473
1915	2,419	19,071			

HONDURAS.

Cement exported from the United States to Honduras, fiscal years ending June 30, 1913–1918.

Year.	Quantity (metric tons).	Value.	Year.	Quantity (metric tons).	Value.
1912	2,275	$20,590	1916	2,740	$25,841
1913	1,281	14,254	1917	1,268	15,116
1914	2,585	29,692	1918	1,751	26,482
1915	4,911	57,859			

HONGKONG.

Concrete for June, 1918, page 110, cement-mill section, says:

The chief Hongkong cement interest—the Green Island Cement Co.—which has long been one of the principal cement interests in the Far East, has earned during the past year (1917) a gross profit of $495,255 Hongkong currency, as compared with

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$610,150 the previous year. The difference is ascribed to the high price of fuel, the shipping difficulties, the high exchange value of silver, and the difficulties of securing raw materials. As to fuel the manager of the cement company referred to stated at the annual meeting that it is now paying $32 local currency, or $24 gold, for coal for which it paid $20 local currency, or $6 gold, at exchange current a year ago, and $10 local currency, or $6 gold, at exchange current the year before.

The company has found it necessary, owing to disturbed conditions in China and owing to the alleged hostile action on the part of Chinese interests, to go all the way to Tonkin for most of its limestone, although stone has come forward from China in larger supplies the past year.

Trade with the Philippines during the past year remained at about the same volume as the previous year, the shipments to the islands being 3,150 short tons; but the value increased from $61,838 for 1916 to $106,261 for 1917. The business is far below its normal volume, however, the value of the exports in previous years being $78,412 in 1915, $111,476 in 1914, $160,289 in 1913, $239,194 in 1912, $349,616 in 1911, and $265,638 in 1910. Since 1911, when it reached its highest point, cement from Japan, Indo-China, North China, and from local sources has been supplying the Philippine market.

No regular trade from United States to Hongkong—1914, 335 barrels, at $425; 1916, 41 barrels, at $103.

ITALY.

Cement imported into Italy, 1910–1914, in metric tons.

Quick-setting cement.

Country.	1910	1911	1912	1913	1914
Austria-Hungary					15
France					7,968
	13,047	14,755	14,041	11,770	7,983

Other cements.

Austria-Hungary					1,066
France					3,596
Germany					22
Switzerland					17
Italian goods returned					74
	7,609	8,331	6,850	5,450	4,775

Cement exported from Italy, 1910–1914, in metric tons.

Quick-setting cement.

Country.	1910	1911	1912	1913	1914
Albania					9
Austria-Hungary					217
France					38
Germany					45
Portugal					72
Switzerland					1,376
India and Ceylon					278
Turkey in Asia					10
Argentina					410
United States					22
Ship stores:					
Italian					10
Foreign					3
Total foreign					2,490
Eritrea					1,728
Somaliland					54
Tripoli					249
Total Italian					2,031
Grand total	1,698	2,574	5,696	10,136	4,521

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Cement exported from Italy, 1910–1914, in metric tons—Continued.

Cement not quick setting.

Country.	1910	1911	1912	1913	1914
Albania					307
Austria-Hungary					334
France					123
Malta					39
Montenegro					11
Portugal					27
Spain					335
Switzerland					2,978
Turkey in Europe					1
Cyprus					45
Australia					2
India and Ceylon					697
Turkey in Asia					538
Egypt					3,854
Morocco					78
Tunis					8
Argentina					1,821
Brazil					235
Chile					2
Cuba					298
Salvador					10
United States					2,175
Uruguay					224
Venezuela					1
Ship stores:					
Italian					29
Foreign					3
Total foreign					14,175
Eritrea					1,445
Somaliland					501
Tripoli					15,605
Total Italian					17,551
Grand total	4,975	7,437	39,534	39,600	31,726

JAMAICA.

Cement exported from the United States to Jamaica, fiscal years ending June 30, 1912–1918.

Year.	Quantity (metric tons).	Value.	Year.	Quantity (metric tons).	Value.
1912	1,679	$12,349	1916	9,299	$75,494
1913	3,514	26,928	1917	5,855	60,766
1914	3,161	25,400	1918	5,893	78,995
1915	4,003	32,433			

Cement imported into Jamaica, 1902–1915, in metric tons.

1902	3,326	1907	4,984	1911	14,711
1903	3,381	1908	13,552	1912	12,174
1904	5,148	1909	17,261	1913	11,934
1905	3,918	1909 [1]	18,100	1914	6,455
1906	3,538	1910	13,778	1915	7,982

MARTINIQUE.

Value of cement imported into Martinique, 1913–1916.

Country.	1913	1914	1915	1916
United States	(a)	$9,564	$9,364	$17,812
All countries	$22,386	24,530	25,047	21,737

a Not given.

[1] Years ending Dec. 31; preceding years ending Mar. 31.

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Cement reexported from Martinique, 1912 and 1914, in metric tons.

Country.	1912	1914
French colonies	9.0	0.4
Haiti	2.0	.5
Other countries	.2	.....
	11.2	.9

MEXICO.

Lime, hydraulic lime, Roman and Portland cements imported into Mexico, fiscal years ended June 30, 1910–1912, in metric tons.[a]

Country.	1910–11	1911–12	Country.	1910–11	1911–12
Germany	25,071	10,460	Holland	344	.....
Austria	61	15	British Honduras	4	7
Belgium	4,534	4,044	Italy	.2	.2
Denmark	268	30	Japan	2	.....
Spain	1	2	Norway	405	.....
United States	18,265	17,939	Sweden	48	20
France	1,055	550			
Great Britain	12,360	18,016		62,483.2	51,128.2
Guatemala	65	45			

[a] Classification reads: Cal común, cal hidráulica, cemento romano ó de Portland, y carbonato de cal ó blanco de España. (Common lime, hydraulic lime, Roman or Portland cement, and carbonate of lime or Spanish white.)

Cement exported from the United States into Mexico, fiscal years ending June 30, 1912–1918.

Year.	Quantity (metric tons).	Value.	Year.	Quantity (metric tons).	Value.
1912	26,412	$250,421	1916	18,662	$186,260
1913	32,197	276,508	1917	17,625	231,572
1914	12,493	124,755	1918	21,479	324,298
1915	18,016	185,087			

NEW CALEDONIA.

Cement imported into New Caledonia, 1912 and 1914, in metric tons.

Country.	1912	1914
France	1,073.3	889.1
Belgium	693.0	782.1
Australia	81.9	83.6
Other countries	.....	219.2
	1,848.2	1,974.0

Cement reexported from New Caledonia, 1912 and 1914, in metric tons.

Country.	1912	1914
New Hebrides	115.4	77.6
French colonies	.....	198.2
Other countries	.....	50.0
	115.4	325.8

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NEW ZEALAND.

Lime and cement works in New Zealand.

	1905-6	1910-11	1915-16
Number of works	20	17	16
Number of hands employed	280	456	550
Amount of wages paid	$166,673	$262,470	$319,038
Amount of horsepower	1,175	3,586	6,854
Approximate value of land	$85,480	$220,399	$156,906
Approximate value of buildings	$114,553	$212,423	$264,124
Approximate value of machinery and plant	$368,112	$811,124	$1,173,980
Value of material used	$176,415	$393,612	$351,258
Total value of manufactures	$524,000	$898,774	$1,288,002

Cement exported from the United States to New Zealand, fiscal years ending June 30, 1912-1918.

Year.	Quantity (metric tons).	Value.	Year.	Quantity (metric tons).	Value.
1912	62	$548	1916	58	$423
1913	27	295	1917	10	80
1914	99	1,846	1918	11	163
1915	2	19			

Concrete for October, 1918, page 44, cement-mill section, quotes as follows:[1]

New Zealand has passed through a nine months' period of selling cement below cost. A new and large company started its operations shortly after 1912 and put cement on the market during the early months of 1917, but owing to the war conditions trade fell off very considerably, the result being a cutting of prices.

The outcome has been an amalgamation of the three companies in the immediate neighborhood of Auckland—viz, the Dominion Portland Cement Co. (Ltd.), the New Zealand Portland Cement Co. (Ltd.), and the Wilsons Portland Cement Co. (Ltd.), under the name of Wilsons (N. Z.) Portland Cement (Ltd.), with a paid-up capital of $3,000,000. George Elliott and F. W. Wilson (formerly of Wilsons Cement Co.) have been appointed chairman of directors and secretary, respectively. Mr. Reed, of the New Zealand Co., has been appointed sales manager, and T. H. Wilson, of the Wilsons Co., has been appointed works manager and engineer of the three plants, with F. Rhodes, of the New Zealand Co., as assistant.

The subjoined abstract describing the plant of the Dominion Portland Cement Co. (Ltd.) is taken from Concrete for May, 1918, page 43, cement-mill section:

The plant of the Dominion Portland Cement Co. (Ltd.) is located at Tikorangoi, on Whangarei Harbor, Auckland, New Zealand, about 60 miles due north of the city of Auckland.

The materials used are high-grade limestone and argillaceous cement rock, which are obtained directly back of and about three-quarters of a mile from the plant.

Quarry: Steam shovel loading to 7-ton quarry cars.
Crushing: No. 6½ gyratory crushers, limestone to rolls, cement rock to hammer mills.
Rock driers: 2 by 7 by 70 foot rotary brick-lined driers.
Storage: 40 hours run.
Raw mill: 6 by 42 inch Fuller mills, fan discharge—75 horsepower vertical motors.
Storage: 30 hours run (kiln storage).
Kilns: 2 by 8½ by 160 foot four-tire rotary kilns.
Coolers: 2 by 7 by 70 foot rotary coolers.
Clinker storage: 40,000 to 45,000 barrels.
Finish mill: 4 by 57 inch Fuller dreadnaught mills.

[1] Letter from an official of Wilsons Portland Cement (Ltd.), Portland, Whangarei County, New Zealand.

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Stock house: 15 bins, 2,000 barrels capacity each.
Coal supply: By water or rail.
Coal crushers: 24 by 18 inch crushing rolls to 1 inch or less.
Coal driers: 5½ by 42 foot indirect fired rotary drier.
Coal pulverizers: 2 by 42 inch Fuller mills.
Electric power: From hydroelectric installation owned by company transmitted at 33,000 volts, transformed to 400 volts, 3 phase, 50 cycles.
Plant capacity: 1,600 barrels per day.

The Cement Era of February, 1917, page 74, says:

The Dominion Portland Cement Co. mill is larger than all other cement plants in New Zealand combined. The company is formed entirely of New Zealand capital and it is intended to send a good deal of the product to Australia, 1,200 miles away, which is not a big freight distance for that part of the world.

Cement imported into New Zealand, 1913–1916, in metric tons.[a]

Country.	1913	1914	1915	1916
United Kingdom	7,062	7,249	1,790	241
New South Wales	2	.....	2	.....
Germany	12	11	.....	.....
United States	10	88	6	17
Other countries	.....	.....	35	.....
	7,086	7,348	1,833	258

[a] British import tariff, 2s. per barrel; additional preferential tariff, 2s. per barrel.

Cement exported from New Zealand, 1913–1916, in metric tons.

Country.	1913	1914	1915	1916
Australia	2,431	3,602	10,749	6,012
Fiji Islands	2,904	1,526	2,209	1,176
Society Islands	170	138	130	102
Samoa	.....	3	157	247
Tonga	.....	126	221	.....
Other countries	158	.....	8	46
	5,663	5,395	13,474	7,583

NICARAGUA.

Cement exported from United States to Nicaragua, fiscal years ending June 30, 1912–1918.

Year.	Quantity (metric tons).	Value.	Year.	Quantity (metric tons).	Value.
1912	362	$3,775	1916	1,306	$13,745
1913	495	5,386	1917	1,917	23,322
1914	800	9,361	1918	1,979	26,774
1915	914	8,57[illegible]			

Cement imported into Nicaragua, 1911–1917, in metric tons.

Country.	1911	1912	1913	1914	1915	1916	1917
United States	221.6	439.1	632.9	805.6	1,151.5	1,534.9	1,462.8
Germany	455.6	1,468.9	580.9	536.7	.2	.....	.....
England	85.7	34.9	71.1	185.7	40.8	.....	.....
France	20.3	.....	.....	.....	.....	.....	.....
Italy	11.0	0.1	.....	.....	.....	.....	.....
Other countries	63.1	48.9	30.8	75.[illegible]	6.1	.....	1.6
	857.3	1,991.9	1,315.7	1,603.1	1,198.6	1,534.9	1,464.4

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PANAMA.

Cement exported from the United States to Panama, fiscal years ending June 30, 1912–1918.

Year.	Quantity (metric tons).	Value.	Year.	Quantity (metric tons).	Value.
1912	291,530	$2,572,030	1916	123,740	$963,881
1913	209,300	1,848,805	1917	62,964	575,446
1914	144,695	1,146,456	1918	41,157	472,285
1915	121,215	932,984			

Cement imported into Panama, 1912–1915, in metric tons.

Country.	1912	1913	1914	1915
United States	6,770.4	12,651.9	9,451.3	10,239.5
Germany	149.8	285.5	.....	.....
Spain	2.1	16.1	.....	.....
Italy	2.9	.....	.....	.....
Belgium	.....	225.4	.....	.....
Great Britain	.....	.....	.....	0.3
China and Japan	.....	.....	.....	3.6
	6,925.2	13,178.9	9,451.3	10,243.4

PARAGUAY.

Production, none; exports, none; imports, none ordinarily, but in 1916–1918 considerable Portland cement imported for building packing plant of International Products Co. It was credited to Argentina, the point of transshipment.[1]

PERU.

Cement Era for March, 1917, page 78, says:

An American engineering chemist sailed February 24 on the steamship *Pastores*, of the United Fruit Co. Line, for South America, where he has accepted a position as factory manager for the Compañía peruana de cemento Portland, Lima, Peru.

Cement exported from the United States to Peru, fiscal years ending June 30, 1912–1918.

Year.	Quantity (metric tons).	Value.	Year.	Quantity (metric tons).	Value.
1912	10,177	$77,138	1916	12,987	$103,272
1913	16,029	123,177	1917	12,530	125,367
1914	13,431	109,902	1918	15,233	203,745
1915	12,202	94,313			

RUSSIA.

Concrete for June, 1917, page 113, cement-mill section, gives the following abstract of an article in the journal of the Russian-American Chamber of Commerce, Moscow, January, 1917:

Previous to the war, development had already been noticed in the cement industry. According to data published at the congress of cement producers in 1915, the production for four recent years was as follows: 1912—10,000,000 barrels of 10 poods (361.13

[1] Graham, W. B., War Trade Board Bur. Research.

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pounds) each [or about 1,638,000 metric tons]; 1913—12,920,000 barrels; 1914—20,000,000 barrels (estimated); 1915—28,000,000 barrels (estimated). The number of cement works was 33 in 1912 and was expected to reach 66 in 1915. However, a number of the new works included in the latter estimate were still under construction, and part of their equipment ordered in Germany had not been delivered. The average output of each concern, which in 1912 was about 300,000 barrels, reached about 425,000 barrels in 1915. Few works are now constructed in Russia with an annual output of less than 500,000 barrels.

On January 1, 1911, the capital of the six cement companies whose shares were quoted on the Petrograd exchange aggregated $4,341,000; on January 1, 1914, the 11 cement-producing concerns quoted on the same exchange represented a capital of $19,956,000. The average capital was thus $721,000 in 1911 and $1,803,000 in 1914. The dividend paid by one company increased from 4.5 per cent in 1910 to 25 per cent in 1912; by a second company from 8 per cent in 1910 to 14 per cent in 1912; and by a third company from 12 per cent in 1910 to 24 per cent in 1912.

Although the cement industry was developing rapidly in the last years before the war, it will be necessary to increase the production five to ten times in order to avoid a cement famine after the war. There are unfortunately no firms in Russia to undertake the construction of cement works. Previous to the war such construction was carried out by German firms and one Danish firm, but the American industry producing the equipment for cement works could very well compete with these firms. The cement industry in Russia is also regarded as a promising field for the investment of American capital.

ST. PIERRE.

Cement imported into St. Pierre, 1912 and 1914, in metric tons.

Country.	1912	1914
France	35.0	28.8
United States	27.6	1.2
Canada	3.2	22.0
	65.8	52.0

The reexports of cement from St. Pierre in 1912 and 1914 were to Newfoundland and amounted to 5.2 metric tons in 1912 and to 4.7 tons in 1914.

SALVADOR.

Cement imported into Salvador, 1914–1916.

Country.	1914		1915		1916	
	Quantity (metric tons).	Value.	Quantity (metric tons).	Value.	Quantity (metric tons).	Value.
United States	1,193	$11,651	3,370	$35,334	4,618	$49,612
All countries	3,349	30,265	3,568	38,237	4,618	49,612

Cement exported from United States to Salvador, fiscal years ending June 30, 1912–1918.

Year.	Quantity (metric tons).	Value.	Year.	Quantity (metric tons).	Value.
1912	337	$3,619	1916	3,692	$37,150
1913	1,369	13,536	1917	7,195	85,375
1914	1,322	14,638	1918	4,664	68,256
1915	2,635	26,194			

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SOUTH AFRICA.

In Africa there are two large cement works—the Pretoria Portland Cement Co., which was established some years ago, and the Whites South African Cement Co., a subsidiary company of the Associated Portland Cement Manufacturers of England. With the decreased shipping facilities for cement from Europe to Africa, both of these plants have been very busy. [1]

Cement imported into South Africa, 1911–1917, metric tons.[a]

Country.	1911	1912	1913	1914	1915	1916	1917
United Kingdom	50,885	54,511	59,267	31,741	14,733	15,838	7,743
Belgium	15,039	14,381	10,855	3,035	1	.....	.....
Denmark	5,318	7,987	4,317	6,495	9,592	5,943	759
France	14	92	.....	.....	.....	.....	.....
Germany	2,991	2,900	3,351	2,415	224	1	.....
Holland	5	47	.....	.....	.....	.....	.....
Italy	4	5	5	.....	.....	.....	.....
Norway	148	315	131	277	113	91	.....
Sweden	1,446	2,541	2,544	573	206	1	10
United States	25	30	31	1	6	41	.....
	75,875	82,809	80,501	44,537	24,875	21,915	8,512

[a] Preference of 6 cents per barrel (400 pounds) as rebate on British goods originating in Great Britain or colonies.

SPAIN.

Owing to the falling off of imports the production of cement in Spain has largely increased, and that country now has nine plants devoted to the making of Portland cement, five of which are of comparatively recent construction. They produce now 350,000 tons of cement and are being increased to a capacity of 500,000 tons. This will take up any demand for cement from the outside. An interesting fact is that there are 61 plants in Spain making a natural cement, of which 255,000 tons were produced in 1914.[1]

SUDAN.

Cement imported into Sudan, 1907–1915, in metric tons.

1907	20,917	1912	3,521
1908	18,525	1913	5,071
1909	1,532	1914	4,999
1910	4,581	1915	1,272
1911	4,775		

SWEDEN.[2]

The manufacture of cement in the form known as Portland cement is not of very old date in Sweden, though the sort of hydraulic mortar made of burnt alum shale powder and lime was formerly used in connection with earlier canal structures. Cement was employed as early as 1860, but then only to the extent of 1,180 tons. The first cement factory in Sweden was established at Lomma, in Skane, in 1871, on the initiative of Prof. Otto Torell and Otto Fahnehjelm, an engineer. Clay of suitable quality is to be found there in unlimited quantities, and lime was obtained from the neighboring place of Limhamn and sent by sea to Lomma. This was the beginning of the Scanian Cement Co., the first manager of which, R. F. Berg, has done a great deal toward furthering the development of the cement industry in Sweden. In Sweden the natural conditions necessary for the manufacture of cement are amply satisfied, owing to the great resources of suitable raw material, and, after the Lomma factory (which was closed in 1904) other factories were started at Limhamn (established by the Scanian Cement Co.); Visby, 1885; Öland, 1888; Hällekis, 1892; and, at Klagshamn and Maltesholm, 1898. The latest factory is the Ifö Cement Factory

[1] Lesley, R. W., address before the Portland Cement Association, Dec. 14, 1916.
[2] Sweden, Historical and Statistical Handbook, 1914.

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(1909). The sale of the products of all these factories is negotiated through the Swedish Cement Selling Co., of Malmö. Owing to its excellence, this Swedish cement has obtained a first-class reputation, also for export, at first under the name of Lomma cement.

The output of the factory at Lomma was at first 20,000 casks of cement yearly. The capacity of production of the Limhamn factory is now about 900,000 casks yearly. When working at full pressure, all the Swedish factories can now produce about 2,500,000 casks yearly. The product was 339,618 tons (1,187,000 casks) in 1912, with a value of 9,621,000 kronor. Fourteen hundred and forty-seven workmen were then employed in the manufacture of cement. With the year 1889, when cement became subject to a duty of 40 öre per 100 kegs, the manufacture rose somewhat, and later increased rapidly when the duty was in 1895 increased to 60 öre per 100 kegs. The manufacture and export have steadily increased since.

Of the total exports in 1912, amounting to 127,141 tons, 42,420 tons went to Russia, 33,286 tons went to Argentina, 22,155 tons to the Sunda Islands, 14,810 tons to Finland, and 12,189 tons to Denmark; the remainder was distributed over British South Africa and Brazil.

Statistics of cement industry in Sweden.

Year.	Production.	Imports.	Exports.	Consumption.
1875	$59,228	$71,020	$31,892	$98,356
1876–1880	106,664	76,380	54,672	128,372
1881–1885	169,912	87,904	88,976	168,840
1886–1890	284,884	96,480	83,080	298,284
1891–1895	490,172	18,492	260,228	248,436
1896–1900	890,296	18,170	245,140	663,326
1901–1905	1,031,666	69,680	177,416	923,930
1906–1910	1,831,539	100,098	279,310	1,649,379
1910	2,272,640	185,188	641,056	1,816,772
1911	2,236,353	170,689	640,627	1,766,415
1912	2,578,428	116,848	902,892	1,792,384

TRINIDAD.

Cement exported from the United States to Trinidad, fiscal years ending June 30, 1912–1918.

Year.	Quantity (metric ton).	Value.	Year.	Quantity (metric ton).	Value.
1912	1,027	$7,194	1916	6,238	$49,112
1913	1,915	13,988	1917	8,895	80,373
1914	2,284	19,543	1918	6,113	81,355
1915	2,775	21,179			

UNITED KINGDOM.

Concrete for February, 1918, page 21, cement-mill section, quotes from a letter from H. E. Brooks, managing director of the Associated Portland Cement Manufacturers (1900) (Ltd.), London, England, as follows:

Since my previous letter was penned a very considerable change has taken place, and this is due in the main to two causes:

1. The scarcity of timber, consequent on the difficulty of obtaining supplies from the Scandinavian countries, causing the substitution of Portland cement concrete for timber and steel in all kinds of building operations for war purposes, both within the United Kingdom and in the war zone.

2. Stocks, which were accumulating in the early months of the last year, have for some time been falling. Only very moderate quantities are now in maker's hands,

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and there is every prospect of further reduction, notwithstanding the presence of winter.

At the present time the scarcity of labor due to the war is being acutely felt and constitutes the most serious of our difficulties in the production of cement; but as almost all the cement now used here is for purposes directly or indirectly necessary for the prosecution of the war, the various government authorities concerned are giving us what help they can to improve the position. Those * * * who have taken note of the varying conditions of the cement trade in other lands * * * may be interested to learn that, although the production here is still only about one-half the pre-war tonnage, conditions have improved, and the increased demand seems likely to continue.

Domestic cement exported from the United Kingdom, 1907–1917, in metric tons.

Country.	1907	1908	1909	1910	1911	1912	1913	1914	1915	1916	1917
China	21,952	1,917	31	254	101	.....	.....	.....	.....	.....	.....
Netherlands	4,586	6,990	4,124	5,980	6,528	3,638	4,916	20,838	4,118	1,304	48,930
Portuguese East Africa	3,182	8,671	10,604	20,623	9,961	9,733	8,075	5,309	2,098	1,421	2,271
Spain	4,293	4,446	1,693	378	613	1,037	13,834	682	1,000	416	754
Turkey	.....	.....	.....	.....	.....	6,786	3,191	.....	.....	.....	94
Egypt	53,978	44,605	14,432	38,563	40,399	33,392	17,795	5,918	.....	.....	.....
Mexico	.....	.....	.....	.....	[a]12,360	[a]18,016	.....	.....	.....	.....	.....
Brazil	.....	.....	.....	100,449	87,691	79,403	130,367	39,347	.....	.....	.....
Uruguay	.....	.....	.....	9,185	2,392	.....	.....	.....	.....	.....	.....
Argentina	.....	.....	.....	.....	77,708	63,500	114,009	39,459	83,272	60,559	33,744
British India [b]	.....	.....	85,140	84,784	111,886	102,346	155,350	152,842	147,057	98,846	23,755
Australia	.....	.....	.....	.....	.....	39,101	32,458	(b)	[a]36,310	[a]25,211	[a]1,891
New Zealand	.....	.....	.....	.....	.....	.....	7,062	7,249	1,790	241	.....

[a] Fiscal year. [b] Half a year lacking on account of change to fiscal year.

URUGUAY.

Concrete for August, 1918, page 106, cement-mill section, says:

At present practically all cement used in Uruguay is produced by the Fábrica uruguaya de Portland, of Messrs. Metzen-Vincenti y Cía., located at Sayago (Montevideo). This mill began operations shortly before the outbreak of the European war, after thorough experiments with native materials running back as far as 1909 had been made by German experts. It has a concession from the Uruguayan Government giving it certain privileges as respects taxation, which concession expires in 1928. The company has its own limestone quarries situated in the Department of Minas. Stone is extracted by modern methods including the use of compressed air drills. The original equipment for the making of cement was furnished and installed by the Amme, Gieseche und Konegen Aktien-Gesellschaft, Braunschweig, Germany. The plant has subsequently been expanded and now has a capacity of over 400,000 barrels (about 68,400 metric tons) per year. The plant and its dependencies represent an investment of $827,000. The product, which is known as the "Metzen" brand, is said to be a gray cement of very good quality, comparing favorably with imported cement. It is already well known in Argentina. It is put up for sale in 50-kilo (110 pounds) sacks, and barrels, weighing 180 kilos (397 pounds) gross and 170 kilos (375 pounds) net.

Metzen cement was quoted on April 1, 1918, at 2.85 pesos ($2.95) per sack of 50 kilos and 9.80 pesos ($10.13) per barrel of 180 kilos gross. Prices are for cement delivered at Montevideo or at railway station or dock (Montevideo). The company buys back sacks at 8.3 cents each.

The import duty is equivalent to a specific rate of 25.5 cents (United States) per 100 pounds gross. There are, further, certain minor charges, which, according to an importer, bring the actual entrance charges on imported cement up to roughly 1.05 pesos ($1.09) per barrel. The import duty and charges stated are applicable to cement imported from all countries.

The remarkable falling off of imports of cement, as compared with the pre-war period, is due to the lack of activity in building and construction work, the difficulty of securing cement from abroad, and the rapid development of the home industry. As a result of the latter, Uruguay is now exporting cement.

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The following extract is from the Engineering and Cement World, of October 5, 1918:

The Government of Uruguay has appealed to the Philadelphia Chamber of Commerce to interest American cement manufacturers in the erection of a modern cement plant in or near Montevideo. Uruguay has been dependent for its manufactured cement on a plant owned and operated by Germans, who have charged exorbitant prices for their product and have been independent and arbitrary in their dealings with the Uruguayan Government.

The communication sent to the Philadelphia Chamber of Commerce states that the Uruguayan Government desires to boycott this German plant and to induce American cement manufacturers to consider favorably the erection of a plant at Montevideo, and that the Government is willing to allow a number of concessions.

Cement exported from the United States to Uruguay, fiscal years ending June 30, 1912–1918.

Year.	Quantity (metric tons).	Value.	Year.	Quantity (metric tons).	Value.
1912	1,637	$11,890	1916	2,100	$16,127
1913	1,347	10,411	1917	714	8,966
1914	483	3,632	1918	837	12,040
1915	1,041	7,682			

Portland cement imported into Uruguay, 1910–11, in metric tons.

Country.	1910	1911	Country.	1910	1911
Germany	11,901.0	15,520.0	France	10,256.9	14,546.5
Argentina	2,059.4	2,084.0	Italy	133.8	166.4
Austria	60.4	590.4	United Kingdom	9,125.1	2,360.1
Belgium	5,118.9	11,550.4	Netherlands	1,571.0	11,343.2
Brazil	.4	.1		40,386.3	58,971.0
Spain	26.1	93.1			
United States	133.3	716.8			

Roman cement imported into Uruguay, 1910–11, in metric tons.

Country.	1910	1911	Country.	1910	1911
Germany	196.7	63.0	France	950.7	1,294.2
Argentina	86.1	47.9	Great Britain	60.0	31.5
Belgium	45.0	.....		1,510.6	1,372.3
Brazil	.....	5.7			
United States	172.1	.....			

VENEZUELA.

Cement imported into Venezuela, 1912–1917, in metric tons.

Country.	1912	1913	1914	1915	1916	1917
Germany	2,967.9	2,600.9	1,303.8	.....	.....	.....
United States	7,980.0	5,989.1	5,236.4	5,874.5	7,180.4	4,606.3
Holland	1,602.3	2,778.9	1,178.2	648.1	1,667.9	550.3
Great Britain	873.3	651.3	90.2	86.4	28.5	.....
Italy	8.6	.....	.....	.....	.....	.....
Trinidad	1,514.3	1,590.9	1,307.1	1,606.7	1,738.4	1,219.0
France	16.7	14.8	8.0	.....	.....	.....
Belgium	.....	241.8	36.1	.....	.....	.....
Spain	.....	.....	.....	.....	36.1	.....
Barbados	.....	.....	.....	.....	11.0	.....
Granada	.....	.....	.....	.....	.....	3.8
Porto Rico	.....	.....	.....	.....	.....	46.0
Other countries	138.3	51.5	47.7	49.4	36.0	1,076.2
	15,101.4	13,919.2	9,207.5	8,265.1	10,698.3	7,501.6

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Cement exported from the United States to Venezuela, fiscal years ending June 30, 1912–1918.

Year	Quantity (metric tons).	Value.	Year.	Quantity (metric tons).	Value.
1912	3,942	$30,714	1916	6,528	$52,529
1913	9,073	72,161	1917	7,049	69,316
1914	6,145	48,870	1918	3,501	51,599
1915	4,622	36,772			

POSITION OF THE UNITED STATES IN THE HYDRAULIC CEMENT TRADE OF THE WORLD.

The following table, prepared by Robert S. Schultz, jr., shows the maximum recent production of cement in all the producing countries of the world, as far as ascertainable, as well as the average normal consumption of cement throughout the world in the years preceding the war or during the war, and indicates the future prospects of the industry. The table shows at a glance the leading position of the United States in the hydraulic cement trade of the world.

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Statistics of the hydraulic cement trade of the world,[a] showing position of the United States.

[Prepared by Robert S. Schultz, jr. Statistics approximate and subject to revision. Quantities in metric tons.]

Country.	Maximum recent production.			Average normal consumption.		Probable maximum exportable surplus.	Probable minimum necessary imports.	Expected effect of known reserves on future output.	Comments.
	Quantity.	Year.	Approximate percentage of world's total.	Quantity.	Year.				
United States	15,938,800	1917	43.23	13,472,200	1911–1914	2,466,600	.....	Possible 5–10 per cent increase in production.	Enormous reserves of raw materials. Production limited by plant capacities. Practically entire export trade is with South America.
North America, exclusive of United States:									
Canada	1,412,300	1913	3.83	1,391,900	1912–1913	20,400	.....	Probable large increase	Industry growing very rapidly before the war. Several new plants completed. No necessity of imports and probable small surplus for export.
Mexico	(b)	.....	.....	61,000	1910–1913	.....	61,000	Possible increase	Several very small mills.
Cuba	103,600	1918	0.28	127,000	1915–1916	.....	23,400	New plant operating	New plant—capacity 600,000 barrels or 103,900 metric tons—completed April, 1918. Controlled by United States capital.
British West Indies and British Guiana.	.....	.....	.....	20,800	1911–1914	.....	20,800	.....	No production known—demand well supplied by imports.
Central America	10,200	.....	0.03	16,300	.....	.....	6,100	Small production	Small mill in Guatemala—will about supply domestic demands. Controlled by United States capital.
South America:									
Argentina	.....	1918	.....	447,000	1911–1914	.....	447,000	Production of 172,720	One plant building—1,000,000 barrels yearly capacity. Raw material available for other plants. Several very small ones operating.
Bolivia, Ecuador	.....	.....	.....	7,500	1910–1914	.....	7,500	.....	
Brazil	.....	.....	.....	562,900	1913	.....	562,900	.....	
Chile	20,300	1914	0.06	167,700	1913	.....	147,400	.....	Two plants operating. Large reserves of raw materials, making possible large production with increased demand.
Colombia	.....	.....	.....	12,200	1917	.....	12,200	.....	
Peru	.....	.....	.....	30,000	1911–1914	.....	30,000	.....	
Uruguay	71,100	1917	0.19	58,700	1911–1913	12,400	.....	No change	One small plant operating. Production sufficient for domestic demand with slight surplus available for export.

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Venezuela, Paraguay	.....	.....	.....	10,700	1916–1917	.....	10,700	.....	One small mill in Venezuela—production insufficient for domestic demand. Paraguay ordinarily uses little or no cement, but in 1916–1917 considerable cement was imported for construction of packing plant.
Europe:									
Austria-Hungary	609,600	(c)	1.65	530,300	1911–1913	79,300	.....	.....	Large pre-war producer. Condition of industry unknown.
Belgium	2,032,000	(c)	5.51	1,207,000	.....	825,000	.....	Great temporary decrease.	Large producer of both natural and Portland grades before the war. Many mills probably destroyed. Some mills known to have been operated by Germans. Will probably require very large imports for reconstruction.
British Isles	3,048,000	1913	8.26	2,361,200	1912–1913	686,800	.....	No probable change.	Industry about stabilized between production and demand prior to war. Exports chiefly to India and eastern South America.
Bulgaria	.....	.....	.....	15,400	1907–1911	.....	15,400	.....	
Denmark	503,900	1913	1.36	278,400	1911–1914	225,500	.....	Probable increase	Industry overdeveloped prior to war. Production and exports restricted by agreement with Germany.
France	1,930,400	1913	5.24	1,494,500	1910–1912	435,900	.....	Temporary decrease	Large production of both natural and Portland grades. Mills mostly small. Many mills in devastated area probably destroyed.
Germany	7,193,300	1912	19.51	6,070,600	1910–1913	1,122,700	.....	Probable large increase	Very large producer before the war. Industry overdeveloped and production restricted by agreement. Exports restricted by agreement with Belgium, England, and Denmark.
Greece	.....	.....	.....	1,000	(c)	.....	1,000	.....	
Holland	2,100	1914	0.01	310,900	1910–1913	.....	308,800	.....	One very small mill.
Italy	847,300	1910	2.30	823,000	.....	24,300	.....	Probable increase	Large production, mainly of natural grade. Number of mills being modernized before the war.
Norway	(b)	.....	.....	23,900	1911–1914	.....	23,900	Probable production	At least one company organizing. Probable sufficient production for domestic demand.
Portugal	.....	.....	.....	36,000	1913	.....	36,000	.....	
Rumania and Serbia	16,300	1911	0.04	19,600	1910–1913	.....	3,300	.....	Sixty-six plants either active or under construction in 1915. Effect of war unknown.
Russia, Finland	457,200	1915	1.24	635,000	1912–1914	.....	177,800	Probable increase	Probable large demand with return of civil stability.
Spain	525,300	1912	1.42	601,500	1912–1914	.....	76,200	Possible increase	Producer of both natural and Portland grades before war. Mills being modernized. Production will probably supply domestic demand.
Sweden	391,200	1913	1.06	249,900	1912–1914	141,300	.....	No probable change.	Domestic consumption will probably increase slightly. Exports principally to Russia and to Argentina.
Switzerland	254,000	(c)	.69	237,300	1911–1914	16,700	.....	.....	Large producer.
Turkey	50,800	1914	.14	57,400	1911	.....	6,600	.....	Two small plants. Production insufficient for domestic demand.

[a] Financial control of production almost entirely in producing countries

[b] Slight.

[c] Estimated.

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Statistics of the hydraulic cement trade of the world, showing position of the United States—Continued.

Country.	Maximum recent production.			Average normal consumption.		Probable maximum exportable surplus.	Probable minimum necessary imports.	Expected effect of known reserves on future output.	Comments.
	Quantity.	Year.	Approximate percentage of world's total.	Quantity.	Year.				
Asia:									
British East Asia, Hongkong.	5,800	1915	0.02	50,800	1911–1914	.....	45,000	.....	No production. Demand supplied largely from China and Japan.
China	67,100	1916	.18	72,500	1913–1915	.....	5,400	Possible increase	Large deposits of raw material. Several mills operating in small way.
Dutch East Indies	.....	.....	.....	103,600	1910–1913	.....	103,600	.....	
French East Asia	77,200	1916	.21	28,200	1914–1916	49,000	.....	.....	Modern mill in Indo-China.
India and British Indies	50,800	1915	.14	254,000	1911–1914	.....	203,209	Probable small production.	Several very small mills in India. Probable field for British expansion.
Japan, Taiwan	823,000	1916	2.23	663,500	1911–1914	159,500	.....	Probable increase	Industry overdeveloped before the war. Production restricted by agreement. Possible large increase if demand warrants.
Korea	.....	.....	.....	28,400	1912–1913	.....	28,400	.....	
Siam	25,400	1916	0.07	33,500	1916	.....	8,100	No change	One modern mill in country under British financial control.
Africa:									
Belgian Kongo	.....	.....	.....	30,500	1910–1913	.....	30,500	.....	
British South and West Africa.	101,600	(a)	.27	121,900	1911–1914	.....	20,300	Increase	Several mills in operation; probable increase in production.
Egypt	.....	.....	.....	82,300	1910–1913	.....	82,300	.....	
French North Africa	50,800	.....	.14	167,600	1910–1913	.....	116,800	.....	
Italian North Africa	.....	.....	.....	101,600	(a)	.....	101,600	.....	Large consumer—quantity not available. No known production.
Madagascar	.....	.....	.....	6,100	1911–1914	.....	6,100	.....	
Australasia (British)	254,000	1913	.69	432,800	1913–1914	.....	178,800	Increase	Several well-equipped mills completed just before the war. Probable large increase in production.
Summary:									
North America	17,454,700	.....	47.34	15,072,900	.....	2,381,800	.....	.....	
Central America	10,200	.....	0.03	16,300	.....	.....	6,100	.....	
South America	91,400	.....	.25	1,296,700	.....	.....	1,205,309	.....	
Europe	17,861,400	.....	48.43	14,952,900	.....	2,908,500	.....	.....	

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Asia	1,049,300		2.83	1,234,500			185,200	
Africa	152,400		.41	510,000			357,600	
Australasia	254,000		.69	432,800			178,800	
World	36,873,400		100.00	33,516,100		3,357,300		
United States	15,938,800		43.23	13,472,200		2,466,600		
Germany and Austria-Hungary.	7,802,900		21.16	6,600,900		1,202,000		
British Empire	4,872,500		13.21	4,715,700		156,800		
France and colonies	2,058,400		5.59	1,696,400		362,000		
Belgium and Belgian Kongo.	2,032,000		5.51	1,237,500		794,500		
Others	4,168,800		11.30	5,793,400			1,624,600	
World	36,873,400		100.00	33,516,100		3,357,300		

a Estimated.

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CONCRETE SHIPS IN 1918.

By Robert W. Lesley.[1]

During 1917 and 1918 every effort was made and every nerve strained to put American troops on the battle front with the least possible delay. American energy was largely concentrated upon the increasing of American shipping in order to provide passage for the millions of soldiers and the millions of tons of material which it was felt were the necessary supply for our part in the war. The Emergency Fleet Corporation, with practically unlimited appropriations, engaged vigorously in the construction of yards for the building of wooden ships and also erected at a number of points along the Atlantic coast enormous yards for the construction of fabricated steel vessels. Even this large program seemed insufficient to meet the emergency, and it was under these conditions that the Concrete Ship Section of the Emergency Fleet Corporation came into existence and began the construction of what were known as "stone ships", as described in the first article on concrete ships published by the Geological Survey in its chapter on cement in Mineral Resources for 1917.

The staff of concrete engineers and naval architects formed to make an exhaustive investigation of the subject and develop designs for concrete ships gathered much valuable information, and early in 1918 contracts were let to the Fougner Concrete Shipbuilding Co., of New York, and the Liberty Shipbuilding Co., of Boston, for the construction by each company of a 3,500-ton concrete vessel according to their own designs, the building of subsequent ships under the contracts being contingent upon the success of the first ship. After a proposition had been brought before Congress to appropriate $50,000,000 for concrete ships, it was found that the Emergency Fleet Corporation itself had funds available to do this work, and, in accordance with the plans adopted in the fabricated shipyards built under Government auspices, five yards were established for the construction of concrete ships by agency contract under the direct supervision of the Concrete Ship Section of the Emergency Fleet Corporation. The locations of the yards and the agency contractors were as follows:

Jacksonville, Fla.—A. Bentley & Sons Co.
Mobile, Ala.—Fred T. Ley Co.
Wilmington, N. C.—Liberty Shipbuilding Co.
San Diego, Calif.—Scofield Engineering Co.
Oakland, Calif.—San Francisco Shipbuilding Co.

The original program of construction at these yards provided that each company should have the building of eight 7,500-ton vessels and that these and the two already mentioned above should constitute a building program of 42 vessels with a total capacity of 307,000 tons.

With the adoption of a concrete-ship program by the Emergency Fleet Corporation, general interest was awakened not only in other departments of the Government but also among shipowners generally, and a lively discussion arose between the Shipping Board and the Army Transport Service over the desire of the latter branch to build concrete ships. In the ordinary commercial field, the construction by private yards of concrete vessels was for a time hindered by the attitude of the Shipping Board, which declined to give permission for general construction of vessels of this type by other private yards.

[1] Associate American Society Civil Engineers.

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Contracts for concrete vessels were let by the Navy Department for twelve 500-ton coal barges, by the Inland Waterways Commission for twenty-one 500-ton concrete barges to be used on the New York State barge canal, and by the Army Transport Service for water tank boats, river steamers, and car-ferry floats. The result of all this was that just as the war was approaching its end, namely, in September, 1918, concrete-ship construction was in full swing. The following table indicates the total tonnage either completed or under construction or contract in the year 1918:

Concrete ships and barges in the United States and Canada, in 1918.

	Dead weight tonnage.
Completed:	
S. S. *Faith*	5,000
S. S. *Concretia*, Montreal	350
Ocean Barge & Transport Co., Seattle, scow	550
J. W. Thompson Co., New Orleans, 2 barges	1,100
Louis L. Brown Co., New York, 1 barge	700
Louis L. Brown Co., 1 barge for Navy Department	500
Fougner Concrete Shipbuilding Co., New York, 1 oil barge for Standard Oil Co	370
American Chain Co., Bridgeport, Conn., 1 barge	100
Harrison Barge, Long Beach, N. Y. (800 tons, estimated)	800
Marl Barge, Union City, Mich	300
	9,770
Government work under contract:	
Concrete Ship Department:	
Fifty 3,500-ton cargo ships, Liberty Shipbuilding Co., Brunswick, Ga.	175,000
Five 3,500-ton cargo ships, Fougner Concrete Shipbuilding Co., Flushing, L. I	17,500
Forty-two vessels, forty 7,500-ton oil tankers, with two 3,500-ton cargo ships to be built at five Government and two private yards	307,000
Navy Department:	
Eleven 500-ton coal barges (one completed by L. L. Brown Co.)	5,500
Twenty-one 500-ton barges	10,500
War Department—Army Transport Service:	
Twelve 265-foot car-ferry floats, 1,100 tons	13,200
Five 100-foot water-tank boats (285 tons, estimated)	1,425
Fourteen 130-foot river steamers (390 tons, estimated)	5,450
	535,575
Private contracts:	
One 2,000-ton cargo ship, Houston, Tex	2,000
One cylindrical oil tanker, New Orleans, La. (estimated)	1,500
One oil tanker, Newburgh, N. Y	2,800
One seagoing barge, Vancouver	1,500
Two 225-foot cargo ships, Cleveland, Ohio (estimated)	6,000
Two 150-foot tow barges, Cleveland, Ohio (estimated)	1,200
One barge, 400 tons, Concrete Boat Co., San Francisco, Calif	400
One 600-ton barge, Chas. O. Heyworth, Chicago, Ill	600
One tugboat, 25 tons; 10 barges, 130 tons, International Constructors, Chicago, Ill	1,325
Three oil barges, 400 tons (estimated), Fougner Concrete Shipbuilding Co	1,200
	18,525
Summary:	
Completed	9,770
Government work under contract	535,575
Private contracts	18,525
	563,870

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With the cancellation of many contracts for wooden ships, for fabricated steel ships, and for vessels of other classes by the Emergency Fleet Corporation, the concrete-ship program underwent reductions. At the end of 1918 the total of Government concrete vessels under contract was largely reduced, as is shown by the table below:

Government concrete boats under contract at end of 1918.

Government agency.	Type of boat.	No.	Name of contractor.	Location of yard.
Emergency Fleet Corporation.	3,500-ton freighter	1	Fougner Concrete Shipbuilding Co.	Astoria, L. I.
Do	3,000-ton freighter	1	Liberty Shipbuilding Co.	Brunswick, Ga.
Do	3,500-ton freighters	2	do	Wilmington, N. C.
Do	7,500-ton tankers	2		
Do	7,500-ton freighter	1	San Francisco Shipbuilding Co.	Oakland, Calif.
Do	7,500-ton tankers	2	F. T. Ley & Co	Mobile, Ala.
Do	7,500-ton freighter	1		
Do	7,500-ton tankers	2	A. Bentley Sons	Jacksonville, Fla.
Do	do	2	Scofield Eng. Co	San Diego, Calif.
Navy Department	500-ton harbor lighters	4	Ambursen Construction Co.	Little Ferry, N. J.
Do	do	4	L. L. Brown Co	Peekskill, N. Y.
Do	do	4	S. G. Beskin	Beacon, N. Y.
Railroad Administration. (Construction supervised by Emergency Fleet Corporation.)	500-ton New York Barge Canal barges.	8	Holler-Davis & Flood Co.	Fort Edward, N. Y.
Do	do	4	Caldwell-Marshall Co	Tonawanda, N. Y.
Do	do	5	Grayhaven Shipbuilding Co.	Detroit, Mich.
Do	do	4	Cummings Structural Concrete Co.	Ithaca, N. Y.
War Transport Branch, War Dept.	130-foot river boats	9	(Contracts not completed.)	
Do	100-foot water tankers	5	Great Northern Shipbuilding Co.	Vancouver, Wash.
Do	265-foot car floats	6	Liberty Shipbuilding & Transportation Co.	Cleveland, Ohio.
Do	do	6	L. B. Harrison Co	Athens, N. Y.

The total number of vessels of the 7,500-ton class to be built in the agency yards by the Emergency Fleet Corporation was reduced to 14, distributed as shown in the table, and the work of the other departments of the Government was also reduced from the original plans. In private yards a few barges were under construction at the end of the year, but no private ships were being built.

The concrete shipbuilding program may be said to have been justified by the *Faith*, inasmuch as this cargo steamship, built in San Francisco and launched March 14, 1918, after making the trip described in this report in Mineral Resources for 1917, spent most of the year 1918 on deep-sea voyages. She left Vancouver with a cargo of lumber for Chile, then proceeded north with a cargo of nitrate by way of the Panama Canal to New Orleans, thence with a mixed cargo to Habana, which she left on November 7, 1918, and arrived in New York on November 14 with 20,000 bags of sugar, having made all these journeys without damage or injury and having demonstrated the value of concrete as a shipbuilding material.[1]

It may be said that the year 1918 was deficient in the actual production of concrete ships and that the curtailing of the Emergency Fleet program for vessels of this type may prove a handicap in the future development. On the other hand and in strong contrast to

[1] A photograph of this ship at dock in New York appeared in Leslie's Magazine, Jan. 4, 1919, p. 20.

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this contention, the year 1918 was productive, first, of a practical demonstration in a large way of an actual seagoing steamship of large carrying capacity which made long ocean voyages, and proved her stability and seaworthiness. Coupled with this actual physical demonstration of the value of the concrete ship as a practical means of ocean transportation, there was gathered in the year 1918 a large mass of most valuable scientific and technical knowledge of the construction of concrete ships. The first ship, the *Faith*, may be said to have been built upon faith without great research or prolonged study; her lines were clumsy and her speed was slow. The later vessels constructed or under construction are of more delicate lines, some of them almost yacht-line in form, and represent the aggregate results of deep study by the naval and concrete engineers gathered in the Concrete Ship Section of the Emergency Fleet Corporation. Their problems were not easy.

It was at first thought that ordinary labor could put together concrete ships much more easily than skilled labor could handle ordinary steel ships of fabricated vessels. It was found, however, that the placing of the steel members of the concrete ship was difficult and expensive. The bending alone required great accuracy and large delays in construction. The steel construction had to be finished as a whole, so that the forms might be placed and the concrete poured at one time, thus avoiding spots or cleavage points. Both placing of the plates and the stripping of them from the completed concrete were also full of difficulty, and it was not until a special method of hammering the concrete into place by pounding on the interior forms was developed that it was found possible to get the mix into all the nooks and crannies formed by the interlacing steel wires and rods. The stability and seagoing qualities of the concrete ship having been demonstrated, the engineers were forced as the war emergency began to disappear and commercial requirements became manifest to develop economies in construction and in every way to lighten the concrete ship without destroying its strength. To this end many improvements have been made in the design of the ship and in the handling of the steel members and of the concrete itself. There were no precedents for the concrete ship; no strain studies; no historical figures to refer to either in type of design or in type of construction. Methods, however, are now being developed for improving the bending and placing of the steel, and, more important than all other developments, great progress has been made in lightening the aggregate. This latter improvement has for its purpose the placing of the concrete ship on an economical parity with the steel ship of commerce. A light and strong aggregate has been developed by highly calcining clay in an ordinary rotary cement kiln. This aggregate, crushed to quarter inch and half inch size, makes a 1:2 concrete weighing about 100 pounds per cubic foot and breaking in compression at 4,000 pounds at 28 days. With this aggregate, which is practically light enough to float in water, it is expected that the standard 150 pounds per cubic foot concrete which had hitherto been used will be reduced to 100 pounds and that the present ratio of dead-weight to full-load displacement, which with the heavier concrete stood at 52 for the concrete vessel as compared with 68.6 for the steel ship, will be increased to 62 for the concrete vessel.

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With these figures in mind, the future of the concrete ship seems to depend largely on cost. According to figures given by engineers who have been in close touch with construction work, the cost of steel ships ranges from $210 to $250 per ton complete, whereas that of concrete ships ranges from $150 to $200 per ton. Thus, to take a general average, the original cost of a concrete vessel of 7,500 tons would be $300,000 cheaper than a steel ship of like capacity. In view, however, of the difference in ratio of dead weight to displacement, the concrete ship would be at a material disadvantage as above shown, and it thus becomes a question as between the repairs, operating expenses, and interest charges on the concrete ship as compared with the steel ship of similar size. The concrete ships so far constructed under the Emergency Fleet Corporation will certainly show costs far in excess of those above estimated because of the fact that each of the yards at which these vessels were to be constructed was planned with four ways upon which eight ships were to be built. If, therefore, all the overhead of this extra construction, including blacksmith shops, offices, bending shops, cement warehouses, and administration expenses, is to be charged against the largely reduced number of vessels built in each yard, as compared with the vessels originally planned and contracted for, the concrete ship will appear at a serious disadvantage. It would seem to be a fair statement that the cost of the Government-built concrete ships will not be excessive if each ship is charged only with its percentage of the overhead and other expenses as originally contemplated rather than be charged with the whole burden caused by the reduced output due to cancellation of contracts.

The first of the Government ships was launched on December 4, 1918, at Brunswick, Ga. She was named the *Atlantus* by Mrs. Woodrow Wilson and was christened by Mrs. Matthew Hale, wife of the plant manager. She was built by the Liberty Shipbuilding Co., agent of the Emergency Fleet Coporation. She has 3,000-ton capacity, with 1,400 horsepower, measures 260 feet in length, with a breadth of 43 feet 6 inches, and has a draft of 22 feet 6 inches. She has a 5-inch wall of reinforced concrete, which, compared with the ordinary wooden ship of the same size, averages 19 inches less and is much lighter, the concrete used being of special aggregate developed by the Concrete Ship Section of the Emergency Fleet Corporation and weighing about 118 pounds, as against approximately 150 pounds per cubic foot of the ordinary concrete. The vessel is at sea under the direction of the Emergency Fleet Corporation.

In summing up the status of the concrete ship Mr. R. J. Wig, head of the Concrete Ship Section of the Emergency Fleet Corporation, gave the following statement:

1. All analytical investigations so far made demonstrate that the concrete ship can be designed so as to carry all the strains which come upon a ship just as safely as a steel ship.
2. The tare weight of a concrete hull has been reduced to such an extent by the development of a light-weight aggregate that it has a proportionate carrying efficiency greater than wooden ships and only slightly less than steel ships.
3. All available experience with concrete ships to the present time does not demonstrate any structural weakness which might indicate unsoundness in the theory of design of concrete ships or probable limited life.

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4. While concrete ships of small size are being built in many places throughout the world, the large ship (over 3,000 tons) is being developed in the United States.
5. There is no perceptible difference in the frictional resistance offered by a concrete ship as compared with a steel ship.
6. Our general knowledge of reinforced concrete as compared with steel structures makes the success of its further adoption for ship construction appear a certainty, but actual experience is lacking, and therefore its future can not be predicted with absolute certainty.

Concrete ship construction abroad.—The crying need for ships caused by the submarine warfare was as acute in England as in the United States, and a department of the admiralty was established to construct concrete ships. Some 20 yards were established and contracts for more than 200 boats of all kinds were awarded. The principal one of these is the *Armistice*, of 1,100 tons, built in 1918 at Barrow-in-Furness. It has already made seven voyages with success. According to reports, it has not cost $100 for repairs since leaving the builders' yards. Numerous firms in England, Scotland, and Ireland are building steam tugs and barges of concrete for the admiralty and inland water transport department in England.

France has also been active in concrete ship construction, and Italy has completed a number of barges. Reports of active construction of concrete vessels come from Sweden, where contracts have been made for a number of ships, and also from Spain, where at Malgrat yards plans have been made to build simultaneously 30 concrete vessels, some of them up to 6,000 tons capacity. The first Spanish concrete ship is already at sea.

Even in the Far East construction of this type has gone on—in Cochin-China, at shipyards on Wang Poo River, China, and in Singapore, India. Japan has been testing silico-concrete as a material for shipbuilding, and claims are made that a boat of this material will be 25 per cent lighter than she would have been under ordinary concrete construction and also 25 per cent lighter than if steel had been used.

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MICA.

By WALDEMAR T. SCHALLER.

PRODUCTION.

The mica produced and sold in the United States in 1918, as reported to the United States Geological Survey, amounted to 3,114 short tons, valued at $764,940. The sheet mica marketed in 1918 amounted to 1,644,200 pounds, an increase in quantity of 29 per cent over that of 1917 but a decrease of $22,064, or nearly 3 per cent, from the value, $753,874, in 1917.

The compiled statistics of sheet mica have always lumped together the cut and the uncut; the clear, slightly spotted, and stained, and the heavily spotted and stained; the punch and the washer mica; so that no information is available as to the quantity of clear sheet mica produced with regard to either size or quality. Moreover, not all clear mica is suitable for all high-potential electrical work, and no record is available of the quantity of domestic sheet mica produced that would comply with certain rigid specifications.

The statement that the United States produced so many pounds of sheet mica therefore gives no information as to how much of this was clear, or how much was above a certain size, or how much was suitable for specific purposes. For this reason in making a comparison between domestic production and imports it must be remembered that, whereas the imported mica consists largely of clear sheets of good quality, the domestic product includes all qualities from clear to heavily spotted and stained.

The quantity and value of the scrap mica produced—2,292 short tons, valued at $33,130—were the smallest reported since 1906.

Mica produced and sold in the United States, 1909–1918.

Year.	Sheet mica.		Scrap mica.		Total quantity (short tons).	Total value.
	Quantity (pounds).	Value.	Quantity (short tons).	Value.		
1909	1,809,582	$234,482	4,090	$46,047	4,995	$280,529
1910	2,476,190	283,832	4,065	53,265	5,303	337,097
1911	1,887,201	310,254	3,512	45,550	4,456	355,804
1912	845,483	282,823	3,226	49,073	3,649	331,896
1913	1,700,677	353,517	5,322	82,543	6,172	436,060
1914	556,933	278,540	3,730	51,416	4,008	329,956
1915	553,821	378,259	3,959	50,510	4,236	428,769
1916	865,863	524,485	4,433	69,906	4,866	594,391
1917	1,276,533	753,874	3,429	52,908	4,067	806,782
1918	1,644,200	731,810	2,292	33,130	3,114	764,940

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This table has been compiled from the figures reported by the producers. The total therefore includes cut mica ready for the trade, also uncut, punch and washer, scrap, and a small quantity of run of mine mica, the last being sold in bulk. The prices paid for run of mine mica represent the value of the mica as it is taken from the mine; the finished cut mica brings a much higher price, as it is ready to be used and has had a considerable amount of money spent on it. It is obviously inconsistent to add together the value of mica of two classes differing so greatly, yet this procedure is the only one that can at present be followed. For the output of some of the mines an estimate of 10 per cent of the total run of mine mica as uncut sheet has been made.

The domestic output in 1918 came from 10 States, which, grouped in the order of quantity of sheet mica produced, were North Carolina, New Hampshire, Georgia, Virginia, South Dakota, Alabama, Colorado, South Carolina, New Mexico, and Wyoming. As in previous years, North Carolina led all other States both in quantity and in value of mica produced.

Percentages of mica produced in 1918 by different States.

	Quantity.		Total value.
	Sheet.	Scrap.	
North Carolina	57	46	62
New Hampshire	23	23	15
Georgia	13	2	10
Virginia	5	18	7
All other States	2	11	6
	100	100	100

The annual production of mica, by States, for the years 1912–1918 is shown in the following table. Where less than three producers reported output, the figures are omitted, so that no individual production is disclosed. For some of the years, therefore, the figures of production may not be given.

Mica produced by chief producing States, 1912–1918.

Year.	Sheet mica.			Scrap mica.		*Total quantity.	Total value.
	Quantity.		Value.	Quantity.	Value.		
North Carolina:	*Pounds.*	*Short tons*		*Short tons.*		*Short tons.*	
1912	489,599	245	$219,874	2,492	$36,675	2,737	$256,549
1913	803,462	402	230,674	2,729	37,239	3,131	267,913
1914	274,121	137	171,370	1,789	23,900	1,926	195,270
1915	281,074	141	266,650	2,840	33,943	2,981	300,593
1916	546,553	273	380,700	2,755	41,880	3,028	422,580
1917	643,476	322	543,207	2,180	34,134	2,502	577,341
1918	941,200	471	460,450	1,046	12,930	1,517	473,380
New Hampshire:							
1912	308,047	154	32,238	264	5,100	418	37,338
1913	731,478	366	65,765	692	13,906	1,058	79,671
1914	133,556	67	39,588	600	8,249	667	47,837
1915	96,685	48	59,414	516	7,557	564	66,971
1916	125,502	63	64,386	724	10,853	787	75,239
1917	472,519	236	159,822	680	9,229	916	169,051
1918	376,900	188	106,200	530	7,040	718	113,240

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Mica produced by chief producing States, 1912-1918—Continued.

Year.	Sheet mica.			Scrap mica.		Total quantity.	Total value.
	Quantity.		Value.	Quantity.	Value.		
Georgia:	*Pounds.*	*Short tons.*		*Short tons.*		*Short tons.*	
1912	0	0	$0	0	$0	0	$0
1913	0	0	0	0	0	0	0
1914	(a)	(a)	(a)	(a)	(a)	(a)	(a)
1915	4,949	2	635	0	0	2	635
1916	16,037	8	2,094	0	0	8	2,094
1917	30,534	15	12,141	26	1,400	41	13,541
1918	208,200	104	77,300	40	2,750	144	80,050
Virginia:							
1912	0	0	0	0	0	0	0
1913	4,585	2	4,578	30	572	32	5,150
1914	27,672	14	22,358	153	2,295	167	24,653
1915	10,878	5	9,590	63	828	68	10,418
1916	39,978	20	18,251	182	2,703	202	20,954
1917	68,558	34	22,831	253	2,709	287	25,540
1918	78,500	39	46,200	404	4,280	443	50,480
South Dakota:							
1912	(a)	(a)	(a)	(a)	(a)	(a)	(a)
1913	19,225	10	2,206	591	10,403	601	12,609
1914	27,323	14	1,366	515	6,138	529	7,504
1915	25,992	13	8,230	179	2,684	192	10,914
1916	115,392	58	49,298	527	10,472	585	59,770
1917	37,523	19	5,975	272	5,033	291	11,008
1918	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Alabama:							
1912	0	0	0	0	0	0	0
1913	(a)	(a)	(a)	(a)	(a)	(a)	(a)
1914	32,900	16	3,964	0	0	16	3,964
1915	8,400	4	5,545	23	395	27	5,940
1916	14,132	7	4,955	65	660	72	5,615
1917	18,476	9	3,528	12	280	21	3,808
1918	11,800	6	3,150	0	0	6	3,150

a The figures may not be given, as there were less than three producers.

North Carolina produced in 1918 the largest quantity of sheet mica since 1913. Although the quantity was 46 per cent greater than that in 1917, its value was somewhat less, owing in part to the large quantity of punch mica mined in 1918. The increase in production for the State is a notable one. If mining had not appreciably slackened during the last two months of the year, the production for 1918 would no doubt have been double that of 1917. The concentration of mining on sheet mica is shown by the fact that in 1918 the production of scrap mica was less than half of what it was in previous years.

The production of New Hampshire in 1918 was less than that of 1917 and much less than that of 1913. Extensive preparations for increased production, which began to show results in the fall of 1918, would have materially increased the mica output of New Hampshire had the war continued.

Georgia showed the most surprising increase in its production of mica, an increase due to the extensive development of the Thomaston field, where an excellent mica was mined in considerable quantity. If its record-breaking output can be kept up, Georgia will rank as one of the big mica-producing States of the Union. Virginia also increased its production of sheet mica and the value of all mica mined in the State in 1918 was nearly double that of 1917. In both quantity and value Alabama's output was smaller than that of previous years. South Carolina also turned out only a little mica. South Dakota had but one producer, and Idaho reported no production. Small

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quantities of sheet mica were obtained from Colorado, New Mexico, and Wyoming, but these were little more than prospectors' samples.

Briefly, then, it may be said that the mica-producing States of this country did not do much more than hold their general average. Under the stimulus of needed production and of high prices, they failed to show that their output could be materially increased.

An attempt was made to obtain the figures of production of sheet mica in 1918 in more detail than formerly. Several of the larger companies have sent in returns in great detail; others have not done so, owing in part to the fact that some mica is not sold by the miner in a sheeted and classified form, and also to the fact that some of the larger companies either do not keep an accurate account of the mica they handle or do not wish to furnish the figures to the Government.

On the basis of the returns received, slightly modified in some reports, the production of sheet mica in 1918, as reported, may be given as follows:

Sheet mica produced in the United States in 1918.

State.	Punch.		Uncut.		Cut.		Splittings.[a]		Total sheet.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Lbs.		*Lbs.*		*Lbs.*		*Lbs.*		*Lbs.*	
North Carolina	757,400	$42,590	79,700	$113,700	94,900	$300,180	9,200	$3,980	941,200	$460,450
New Hampshire	306,400	21,900	55,900	42,690	12,600	40,100	2,000	1,510	376,900	106,200
Georgia	37,700	1,860	170,500	75,440	.....	.....	.....	.....	208,200	77,300
Virginia	61,400	23,120	9,100	11,360	8,000	11,720	.....	.....	78,500	46,200
Alabama	8,600	600	3,200	2,550	.....	.....	.....	.....	11,800	3,150
Other States	4,000	200	15,200	8,100	8,400	30,210	.....	.....	27,600	38,510
	1,175,500	90,270	333,600	253,840	123,900	382,210	11,200	5,490	1,644,200	731,810

[a] Refers only to splittings actually produced in the mining or sheeting of the mica. A small portion of the uncut sheet is manufactured into splittings. These are not given in this table but will enter into the figures of consumption.

On the basis of 3 pounds of uncut mica yielding 1 pound of cut mica there was a total production in 1918 of about 700,000 pounds of uncut mica, larger than punch, of all sizes and of all qualities. The actual percentages of the different sizes of uncut sheet mica were determined on an aggregate lot of about 150,000 pounds. Owing to the incompleteness of the reports furnished by some of the mica companies it was not possible to calculate the percentages for a larger quantity of mica. These percentages are as follows, applying only to uncut sheet larger than punch: 1½ by 2 inches, 31 per cent; 2 by 2 inches, 25 per cent; 2 by 3 inches, 23 per cent; 3 by 3 inches, 8 per cent; 3 by 4 inches, 5 per cent; larger, 8 per cent. By applying the percentages obtained to the estimated total of 700,000 pounds of uncut sheet mica produced in the United States in 1918 and adding thereto the figures already given for uncut punch, the estimate of the production of sheet mica, given in the subjoined table, is obtained. The figures include all qualities from the clear to the stained. Perhaps a third of the mica could be graded as clear or only slightly stained. It will be noted that this estimate totals about

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250,000 pounds higher than that given in a previous table. This is due to the fact that the table of production includes cut mica. In the following table of estimated production by sizes, all the cut mica is reduced to its approximate equivalent (three times) of uncut mica. This procedure increases the total figure of estimated production over that of actual production as given by about 250,000 pounds.

Estimated production of sheet mica in the United States in 1918, by sizes.

	Pounds.
Punch	1,175,000
1½ by 2 inches	217,000
2 by 2 inches	175,000
2 by 3 inches	161,000
3 by 3 inches	56,000
3 by 4 inches	35,000
Larger sizes	56,000
Splittings	11,000
	1,886,000

The percentage yield of cut mica according to use, as given on page 640, applied to the 700,000 pounds of estimated production of uncut sheet mica larger than punch, would represent approximately the following yield of domestic cut mica for 1918:

Approximate yield of cut mica larger than punch in the United States in 1918.

	Pounds.
Cut condenser mica	91,000
Cut electric mica	84,000
Cut stove mica	28,000
Other cut mica	21,000
Scrap from cutting	476,000
	700,000

These quantities would represent a maximum, as the 700,000 pounds of mica include the 1½ by 2 inch size (too small for condenser mica) and include also all grades from the clear to the heavily stained and spotted. The 91,000 pounds of condenser mica may therefore be taken as the approximate maximum quantity of that grade that this country can produce in a year. It is easy to see that the domestic mica was not sufficient to supply the demand for condenser mica, which amounted to many hundred thousand pounds in 1918 and was expected to be nearly a million pounds for 1919, if the military program had continued in full force.

WORLD'S PRODUCTION.

In the report on mica in 1916 several tables were given[1] showing the world's production of mica. Later information has made it desirable to revise the figures of that report, and the tables shown below are probably slightly more accurate. The sheet mica is mostly uncut sheet and splittings. The total world's production of such sheet mica averages annually about 3,000 short tons of an average total

[1] U. S. Geol. Survey Mineral Resources, 1916, pt. 2, pp. 296–300, 1917.

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value of $1,000,000 to $1,500,000. This value is considerably increased by the mere processes of splitting, sorting, and trimming. The value of the exported trimmed mica in India, for example, is about three times the value of the crude mica at the mines, and the cut mica or finished product is worth several times the value of the trimmed but uncut mica.

The sheet mica from the United States, as reported, is about 91 per cent uncut sheet, 8 per cent cut sheet, and 1 per cent splittings. That from India is uncut sheet[1] and splittings, the proportions not being known, but estimated as about one-quarter splittings. The Canadian mica is uncut sheet and splittings, the proportion of splittings to sheet not being known, but estimated to be much greater than for the Indian mica. For the other countries the mica reported is essentially trimmed sheet. An approximate idea of the quantity of splittings annually produced in the world can be gained from the table of consumption on page 639.

World's production of sheet mica, 1900–1918, in short tons.

Year.	United States.	India.[a]	Canada.[b]	All other countries.[c]	Total.	Percentage of total represented by production in United States.
1900	228	1,026	(d)	1	.....	.....
1901	180	1,274	(d)	1	.....	.....
1902	187	1,143	(d)	85	.....	.....
1903	310	1,206	(d)	39	.....	.....
1904	334	1,108	(d)	13	.....	.....
1905	462	1,282	(d)	15	.....	.....
1906	712	2,627	287	49	3,675	19
1907	530	2,610	387	54	3,581	15
1908	486	2,677	218	125	3,506	14
1909	905	1,645	185	122	2,857	32
1910	1,238	1,135	379	173	2,925	42
1911	944	1,695	295	207	3,141	30
1912	423	2,192	290	217	3,122	14
1913	850	2,288	552	e190	3,880	22
1914	278	2,026	298	e 21	2,623	11
1915	277	1,357	209	e 58	1,901	15
1916	433	2,430	604	e 79	3,546	12
1917	638	2,291	583	e218	3,730	17
1918	822	3,062	374	(d)	.....	.....

[a] The figures for the years 1900 to 1903 are export figures, as no figures of production are available. The figures for the years 1904 to 1917 represent production and not export. The figures of production are probably smaller than the actual quantity of mica produced. The export figures for any one year may be much greater than the figures of production. For example, in 1917 the production was 2,291 short tons but the exports amounted to 3,496 short tons. For 1918 the production was 3,062 short tons but the exports amounted to 3,364 short tons.

[b] Estimated as one-half of the total reported production of mica in Canada.

[c] The total reported production of mica for the other countries.

[d] No figures available.

[e] Incomplete, as no figures of production are available for some of the countries.

The figures given above under "All other countries" are made up from those contained in the following table:

[1] Although the Madras square-trimmed mica is termed "cut mica" in import schedules, in reality it is uncut trimmed mica.

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Minor quantities of mica produced by certain countries, 1896–1918, in short tons.

Year.	Brazil.	Argentina.	German East Africa.	Transvaal.	Natal and British Nyassaland.	Madagascar.	Ceylon.	Australia.	Total.
1896								[a] 3	3
1897							9	[a] 50	59
1898							4	[a] 1	5
1899							[b]	1	1
1900							0	[b]	1
1901							1		1
1902	12		16		[c] 57		[b]		85
1903	8		[d]		[c] 30		½		39
1904	12		[d]				[b]		13
1905	0		15				0		15
1906	16		27				6		49
1907	5		26				23		54
1908	23	1	87			½	13	[b]	125
1909	5	12	105	[e]		0	0		122
1910	2	21	120	4	25	½	0		173
1911	9	14	110	1	73	[b]	0		207
1912	13	7	172	4	21	0	0		217
1913	11	7	166	[d]	[d]	6	[d]		[e] 190
1914	17	1	[d]	0	[d]	[d]	[d]	3	[e] 21
1915	56	0	[d]	2	[d]	[d]	[d]	[b]	[e] 58
1916	59	7	[d]	13	[d]	[d]	[d]	[b]	[e] 79
1917	106	70	[d]	4	[d]	[d]	[d]	38	[e] 218
1918	[d]	[a] 80	[d]	[d]	[d]	[d]	[d]	0	

[a] Estimated. [c] Natal. [e] Incomplete.
[b] Small production. [d] No information available.

Value of world's production of mica, 1896–1918.

Year.	United States.	India.	Canada.	Other countries.	Total.
1896	$67,191			$1,616	
1897	95,226			30,241	
1898	131,098			3,149	
1899	101,465		$163,000	2,623	
1900	147,960		166,000	506	
1901	118,578		160,000	365	
1902	118,849		135,904	42,480	
1903	143,128		177,857	17,806	
1904	120,316		160,777	4,131	
1905	178,588	$406,328	178,235	8,831	$771,982
1906	274,990	[a]	303,913	25,557	
1907	392,111	[a]	312,599	30,072	
1908	267,925	[a]	139,871	59,442	
1909	280,529	185,691	147,782	68,622	682,624
1910	337,097	264,869	190,385	122,617	914,968
1911	355,804	343,341	128,677	126,473	954,295
1912	331,896	473,442	143,976	136,063	1,085,377
1913	436,060	561,249	194,304	133,675	1,325,288
1914	329,956	428,690	109,061	17,323	885,030
1915	428,769	360,797	91,905	36,327	917,798
1916	594,391	531,638	255,239	62,157	1,443,425
1917	906,782	[a]	358,851	167,908	
1918	764,940	[a]	271,550	[a]	

[a] No figures available.

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The figures given in the preceding table under "Other countries" are made up from those in the following table:

Value of minor quantities of mica produced by certain countries, 1896–1918.

Year.	Brazil.	Argentina.	German East Africa.	Transvaal.	Natal and British Nyassaland.	Madagascar.	Ceylon.	Australia.
1896								$1,616
1897							$5,188	25,053
1898							2,662	487
1899							2,380	243
1900								506
1901							365	
1902	$4,258		$9,600		$28,500		122	
1903	2,611				15,000		195	
1904	3,941						190	
1905			8,831					
1906	6,417		16,707				2,433	
1907	8,669		16,551				4,852	
1908	5,806	$260	51,366			$243	1,718	49
1909	1,597	3,079	62,973	$973				
1910	1,184	30,172	77,864	691	12,463	243		
1911	3,302	3,820	84,745	1,217	33,370	19		
1912	5,455	1,820	117,161	1,767	9,360			
1913	8,233	(a)	126,000			442		
1914	14,207	1,544						1,572
1915	35,470			730				127
1916	54,341	b 2,000		5,767				49
1917	b132,000	b30,000		4,268				1,640
1918a								

a No figures available. b Estimated.

The world's production of splittings as separate from trimmed sheet can not be given, as no figures are available. An approximate estimate of such production is given under the heading "Consumption" (p. 639).

The world's consumption of scrap mica is greater than the figures of actual production of scrap mica for grinding. This is due to the fact that a considerable quantity of scrap mica is accumulated in the cutting of the trimmed sheets into regular shaped pieces. The scrap mica so accumulated would be statistically a duplication of part of the figures given under sheet mica. Yet the following figures show more accurately the actual quantity of scrap mica which is used as such, even though part of it was first recorded as sheet mica.

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World's total production of scrap mica, 1900–1918, in short tons.

Year.	England.a	United States.b	Canada.c	All other countries.d	Total.
1900	0	5,611	(e)	513	.....
1901	3,545	2,261	(e)	637	.....
1902	9,567	1,494	(e)	614	.....
1903	14,781	1,814	(e)	623	.....
1904	7,997	1,263	(e)	561	.....
1905	13,037	1,357	(e)	649	.....
1906	12,750	1,845	431	1,338	16,364
1907	16,368	3,290	581	1,332	21,571
1908	23,701	2,660	327	1,401	28,089
1909	26,796	4,543	277	884	32,502
1910	24,352	4,684	589	654	30,259
1911	28,376	3,984	443	951	33,754
1912	33,557	3,438	435	1,205	38,635
1913	36,944	5,747	828	1,239	44,758
1914	(e)	3,869	447	1,022	.....
1915	(e)	4,098	314	707	.....
1916	(e)	4,649	906	1,255	.....
1917	(e)	3,748	875	f1,200	.....
1918	(e)	2,708	560	(e)	.....

a All derived from the clay pits of Cornwall and Devon.
b The reported production plus one-half of the sheet.
c Three-quarters of the total production reported. One-half of the reported production of mica in Canada is considered as uncut sheet and the other half as scrap. One-half of the sheet probably eventually becomes scrap, giving an estimate for total scrap of three-quarters of the total reported production.
d One-half of the reported production of sheet.
e No figures available.
f Estimated.

STOCKS.

No large stocks of sheet mica are held in this country. The large miners and buyers of domestic mica at times accumulate more or less mica, but in general the mica is cut up and sold as quickly as it is mined. The small stocks held are mainly only sufficient to take care of the orders coming in and do little more than compensate for the fluctuating production. Small stocks are likewise held by the dealers in imported mica, but it is very doubtful if any of the stocks could be considered in the nature of a reserve.

As the splittings consumed in this country are made up almost entirely from foreign mica, the manufacturers of built-up mica board necessarily have to keep up a small reserve of such splittings. The usual reserves held by such companies are estimated to last from two to six months; in a few exceptional cases a year's reserve is maintained.

Information regarding the stocks of sheet mica available for use, if both the quality and size are not accurately given, is not only worthless but absolutely misleading, for the uses to which sheet mica is put depend wholly on the quality and size of the mica.

From the results of investigation undertaken by the Government it soon became apparent that the available stocks of imported sheet mica would serve for the uses demanded by the war program only for a very short time and that the stocks of domestic mica, although much larger in quantity, would also last for a very short time, as so much of the domestic mica was not of the right quality. Hence it was evident that the United States possessed no available reserve of sheet mica of good quality, that the domestic production could not quickly afford the needed relief, and that the country was absolutely

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dependent on imported sheet mica of good quality to meet any materially increased consumption.

Early estimates of the sheet mica required under the war régime because of the rapid increase in Government orders in the manufacture of Government apparatus did not fully anticipate the very rapid growth of the war program and were found to be much too low. The estimates further did not specify whether the sheet mica was to be cut ready for use or whether they referred to uncut mica, even though the ratio of the quantities of cut and uncut mica would be about 1 to 3. A more careful estimate of the Government requirements was therefore undertaken in the summer of 1918, but this estimate, when made, had to be continuously increased, owing to the rapid changes in the requirements of the military program.

The last estimate made in October, 1918, of the requirements of uncut sheet mica, exclusive of splittings, sizes 1 to 6, clear or nearly clear—that is, only slightly stained or spotted—for the calendar year 1919, necessary to the carrying out of Government orders, was that they would amount to at least 1,000,000 pounds, or 500 short tons. At least three-quarters of this would have to be imported muscovite. In addition to this mica of a very good quality, there would be needed a large but unknown quantity of ordinary or stained or speckled mica, used for ordinary electric insulation where the voltage would not be high, and an unknown but large quantity of splittings. Possibly the requirements of all kinds of sheet mica and of splittings would not have been less than 1,000 short tons.

CONSUMPTION.

The consumption of mica in the United States from 1910 to 1918 is shown in the following tables. The first table refers to sheet mica and splittings and all manufactures thereof. The figures are necessarily only approximate, as it is not possible to obtain exact figures. The production of domestic sheet includes all sizes and qualities, cut and uncut. The figures of imported mica do not separate the cut and splittings, and, moreover, as only the value of such mica is given, the quantity has to be estimated. The present figures differ from those given in the report on mica for 1916, and are believed to be more accurate. The export figures represent the total mica exported and are also, in part, estimated.

The second table shows the consumption of scrap and ground mica. The total is made up of the production of domestic scrap attendant on the mining of sheet mica, of the imports of ground mica, and of the scrap mica resulting from the cutting of both the domestic and the imported sheet mica. This quantity has been estimated as one-half of the domestic sheet produced and one-half of the imported sheet, splittings excluded.

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Sheet mica consumed in the United States, 1910–1918, in short tons.

[Estimated.]

Year.	Production.	Imports.		Exports.	Apparent consumption.	Percentage of consumption represented by production.	Percentage of world's production represented by consumption in United States.
		Sheet.	Splittings.				
1910	1,238	481	500	10	2,209	56	76
1911	944	164	500	220	1,388	68	44
1912	423	640	355	190	1,228	34	39
1913	850	560	560	170	1,800	47	46
1914	278	180	500	250	708	39	27
1915	277	220	600	45	1,052	26	55
1916	433	350	850	70	1,563	28	44
1917	638	330	1,275	40	2,203	29	59
1918	822	370	913	40	2,065	40	.....
Average	656	366	673	115	1,580	41	.....

The average yearly consumption for the four-year period 1910–1913 was 1,656 short tons, whereas that for the four-year period 1915–1918 was 1,721 short tons, an increase of only 4 per cent. The annual consumption of sheet mica in the United States may therefore be set at about 1,700 tons. About half of this consumption is domestic mica. The greater portion of the imported half consists of splittings.

The average of the figures given in the table showing the estimated consumption of sheet mica allows a further estimate of the quantities of uncut sheet mica annually consumed according to use. The estimates given below were prepared on the reports submitted by the different mica companies in 1918 as to the use to which the mica was put. Expressed in percentages, they are as follows: Of the domestic uncut sheet mica of all sizes, 71 per cent was used for electric insulation, 23 per cent for stove fronts, 2 per cent for phonograph disks, and 4 per cent for other uses (lamp chimneys and canopies less than 1 per cent); of the imported uncut muscovite sheet, excluding splittings, 82 per cent for electric insulation, 5 per cent for stove fronts, 6 per cent for phonograph disks, 4 per cent for lamp chimneys and canopies, and 3 per cent for other uses. The estimated quantities used are shown in the following table:

Estimated average quantities of uncut sheet mica annually used for different purposes in the United States, in short tons.

	Electric insulation.	Stove fronts.	Phonograph disks.	Lamp chimneys and canopies.	Other uses.
Domestic sheet	466	151	13	3	23
Imported sheet	301	18	22	15	10
Imported and domestic splittings	673	0	0	0	0
	1,440	169	35	18	33

These figures refer to the uncut mica. The finished product—that is, the mica which is cut to regular pattern of the required thinness and inspected, with rejection of uncut pieces—will amount to much less, perhaps from a third for the domestic mica to a half for the imported. The figures also represent the total weight of the uncut

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mica which is first put to the use specified. In the preparation and cutting of the mica, parts of it will be found unsatisfactory for the use first intended and will be put to a different use—generally electric insulation. For example, if a sheet of uncut mica is selected for phonograph disks, when the actual manufacture of the disks is undertaken it may be found necessary to first peel off a thin film of mica, on account of stains, inclusions, or other defects. This thin film is then utilized in electric insulation. After the phonograph disks have been stamped out of the original sheet, there will remain parts of the mica too small to yield additional phonograph disks but sufficiently large to yield several much smaller washers or disks for electric insulation.

It is not possible, with much assurance of accuracy, to give the quantity of mica cut and ready for use for the different purposes. An estimate, which may have to be considerably modified when more detailed figures become available but which is perhaps as close as can now be made, indicates in percentages the quantities of cut and finished (manufactured) mica annually consumed in the different industries somewhat as follows: For uncut sheet mica, domestic and imported, excluding splittings—for electric insulation 76 per cent, for stoves 17 per cent, for phonographs 3 per cent, for lamp chimneys and canopies 2 per cent, miscellaneous 2 per cent. Including splittings, the percentage consumption of all sheet mica is as follows: Electric insulation 86 per cent (46 per cent sheet and 40 per cent splittings), stoves 10 per cent, phonographs 2 per cent, all other uses 2 per cent.

Estimated average quantities of cut and finished sheet mica annually consumed in the United States, in short tons.

	Electric insulation.	Stove fronts.	Phonograph disks.	Lamp chimneys and canopies.	Other uses.
Domestic sheet	187	76	4	1	8
Imported sheet	167	9	7	7	0
Splittings	673	0	0	0	0
	1,027	85	11	8	8

These estimates suggest that about 45 per cent of the total uncut sheet (excluding splittings) is finally used in the finished form, the remaining 55 per cent becoming only scrap suitable for grinding.

The normal annual consumption of sheet mica (including splittings) in the world before 1914 has been estimated to be about 7,000,000 pounds, or 3,500 short tons, distributed as follows:

Estimated normal annual consumption in the United States of sheet mica (including splittings), prior to 1914, in short tons.

United States	1,700
Germany	800
Great Britain	400
India	400
France	100
Italy	50
All other countries	50
	3,500

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The estimated annual consumption and production about balance, and the world thus consumes practically all the sheet mica that is mined. As little or no recovery of mica once used is possible the consumption keeps pace with the production, and it is necessary to produce continuously more and more mica. Such a steady demand is a good incentive to mining, and sheet mica of good quality will always find a ready market, if properly treated, but it is also evident that the natural supply of sheet mica is not inexhaustible and that the time will come when the supply can no longer meet the demand.

No figures are available for the total consumption of mica splittings in the world. The consumption of mica splittings in the United States for the years 1917 and 1918, with an estimated consumption for 1919, are as follows:

Mica splittings consumed in the United States, in short tons.

Origin.	1917		1918		1919 (estimate).	
	Number of consumers.	Quantity (short tons).	Number of consumers.	Quantity (short tons).	Number of consumers.	Quantity (short tons)
India	12	790	13	584	13	663
Canada	10	485	11	329	11	376
United States	7	67	5	64	6	72
South America	.....	0	.....	1	.....	0
	.....	1,342	.....	978	.....	1,111

There are also no figures available showing the actual consumption of scrap and ground mica in the world. The actual consumption is much greater than the recorded production, because a large part of what is recorded as production of sheet mica eventually becomes scrap, being the refuse and trimmings resulting from cutting the uncut mica into cut and manufactured forms.

Ground and scrap mica consumed in the United States, 1910–1918, in short tons.

Year.	Production.	Imports.	Refuse from cutting of domestic and imported sheet.[a]	Consumption.
1910	4,065	[a] 34	860	4,959
1911	3,512	[a] 86	554	4,152
1912	3,226	[b] 171	532	3,929
1913	5,322	145	705	6,172
1914	3,730	202	229	4,161
1915	3,959	172	249	4,380
1916	4,433	181	392	5,006
1917	3,429	46	484	3,959
1918	2,292	6	596	2,894

[a] Estimated. [b] Figures cover last six months of year only.

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Estimated annual world's consumption of scrap mica, in short tons.

Year.	English mica.[a]	Domestic mica.[a]	Refuse from uncut sheet, all sources.[b]	Total.
1910	24,352	4,065	1,652	30,069
1911	28,376	3,512	1,718	33,606
1912	33,557	3,226	1,706	38,489
1913	36,944	5,322	2,210	44,476
1914	(c)	3,730	1,460	.....
1915	(c)	3,959	1,054	.....
1916	(c)	4,433	1,943	.....
1917	(c)	3,429	2,098	.....
1918	(c)	2,292	.....	.....

[a] Actual production of scrap mica.
[b] One-half of the reported production of uncut sheet of the United States, Canada, India, and all other countries.
[c] No information available.

Percentages of ground mica[1] sold in the United States in 1918 for various uses.

[The total quantity sold was about 50 per cent greater than the reported production of scrap mica.]

Patent roofing	60
Wall paper	21
Manufacture of automobile tires[2]	8
Fancy paints, concrete facing, Christmas-tree "snow"	3
Molded electric insulation	3
Annealing, filler for rubber goods,[3] printing, lithography, sizing cotton, etc	[3]
Lubrication (oils, greases, and metal bearings)	2
	100

CONDITION OF INDUSTRY IN 1918.

Early in 1918 it became evident to the manufacturers of radio apparatus and of magnetos that they would have difficulty in obtaining the mica they required. Only a high grade of mica could be used in the condensers that constitute an essential part of these products. A small percentage of the mica so used was mined in the United States, but the bulk of it was imported from India. Canadian amber mica could not be used for this purpose. United States Government specifications, requiring mica, had always insisted on Indian mica, and many manufacturers of mica articles in general showed a marked partiality to Indian mica. It was evident, therefore, that the possibility of a shortage of good-quality sheet mica, largely Indian, was very imminent. To add to the difficulty, the British Government placed all mica coming from India under the control and supervision of the Controller of the Nonferrous Metals Supply of the Ministry of Munitions and no mica was allowed to be shipped from India except to London.

The first organization in the United States looking to Government control of the mica situation was established under the Council of

[1] These figures represent only mica and do not include the clinochlore or chlorite schist produced in Georgia, which in its ground form is very similar to ground mica in its properties and uses. These figures, however, do include some Indian muscovite and Canadian phlogopite. The mica sold in 1918 was also in part derived from production of earlier years. The quantities represented in this table can therefore not be compared with the quantities produced in 1918.
[2] Other than automobile tires.
[3] The largest item is as filler for rubber goods.

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National Defense, where a mica committee was early formed with L. W. Kingsley as chairman. Later F. G. Tryon and C. C. Williams were assigned to a study of mica. In the early part of 1918 the subject of mica was placed in the hands of the War Industries Board, where the mica section was organized, with S. A. Tucker as chairman. Conferences attended by Government officials, mica dealers, and consumers—in all about 22 persons—aided all parties in a better understanding of the situation. The mica section was reorganized and placed under the automotive products division of the War Industries Board in the latter part of March, 1918. The personnel of the section at this time was as follows:

H. J. Adams, in charge, War Industries Board;
Maj. E. J. Knabe, U. S. Army, Quartermaster Corps;
Ensign C. G. Grimes, U. S. Navy, Purchase Division, Bureau of Supplies and Accounts, chemical section.

Early efforts of the mica section were directed by Mr. Adams toward encouraging domestic producers in all parts of the country, regardless of the quality of their mica, and numerous samples sent in were submitted to the Bureau of Standards for tests.

An inventory of mica stocks taken by the War Trade Board was of service, although the information obtained was not sufficiently detailed with respect to the size and quality of the mica.

Meanwhile the United States Geological Survey was formulating plans to study the occurrences of domestic mica with the specific object of finding out to what extent the domestic producers could supply the material required. The investigation was begun in May and continued at intervals throughout the year. The Geological Survey also undertook an extensive statistical inquiry as to stock on hand and as to probable production and consumption, having regard to size, quality, and uses of mica, and embodied the information obtained in recommendations as to procedure both in the mining and in the handling of mica. A large correspondence, accompanied by many samples of mica, was handled directly by the Geological Survey, which continued its long-standing practice of directly assisting the producers of minerals both in mining and in marketing their product.

Mr. Adams resigned in May, 1918, and his place was taken by J. W. Paxton. With the resignation of Mr. Paxton in June the section was reorganized under the chemical division of the War Industries Board, with C. K. Leith in charge. The personnel of the section was as follows:

C. K. Leith, in charge;
Paymaster C. P. Storrs, Navy representative;
Maj. M. V. Ayres, Army representative;
W. T. Schaller, U. S. Geological Survey representative;
D. A. Hall, Shipping Board representative;
E. S. Nelson, War Trade Board representative.

Owing to his assignment to other duties, Maj. Ayres resigned in August, and his place as Army representative was taken by Capt. J. N. Magna, of the Aircraft Production Board. The section held meetings regularly on Tuesday of each week. Other Government departments at various times had representatives at the meetings of the mica section—F. B. Silsbee, of the Bureau of Standards; Roger Chauveau, of the Equipment Division, Signal Corps, and others.

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As there was no assurance of any immediate large increase in the production of domestic mica of the quality needed for war purposes and as the manufacturers consuming mica on Government contracts insisted that increased importations of Indian mica were an absolute necessity, the British authorities, after a thorough investigation of the situation, were requested through the State Department to release additional quantities of Indian mica.[1] To this request the British authorities acceded on condition that the mica released to this country be controlled by the Government. At the same time the British Ministry of Munitions stated that it had established a schedule of fixed prices for Indian mica and submitted the names of two Government-controlled brokers through whom mica should be bought.

With the idea of regulating prices and satisfying the British authorities, the mica section decided to control the importation of mica. It was agreed that the form of Navy order under the national defense act was the most workable means for exerting this control. Consequently on June 7, a Navy commandeering order on all Indian mica was issued. Under this order the Navy by agreement with the Army and the War Industries Board acted for all interested parties, civil as well as governmental. The purpose of this order was to insure, if possible, an adequate supply of high-grade mica under a stable price schedule and to insure the proper disposal of this material by importers. As a price basis for the Navy order the British fixed prices for mica were adopted. To these prices were added importation expenses, including overhead and incidentals, plus a reasonable profit to the importers. Final payment was left to determination by accounting. At the request of the British Government a list of accredited American importers was furnished to the consul general in London in order that all mica purchased might be accounted for. In October, 1918, new Navy orders were drawn changing the terms from a fixed advance payment and cost accounting on each load taken to a definite price, which was 60 per cent in addition to the price in warehouse in the country of origin or so much thereof as was not in excess of English fixed prices on Indian mica of corresponding grade and quality.

An expert in the mica field was obtained by the Navy in the person of Lieut. Charles P. Storrs, for the purpose of handling the situation. Lieut. Storrs divided his time between the Commandeering Board in New York and the War Industries Board in Washington. He was the actual administrator of the affairs of the mica section and the distributor of mica to Government contractors in need of it. He was able to furnish Government contractors with sufficient material to meet their immediate requirements. There was no conflict as to requirements, the various sizes of mica being used for the manufacture of different appliances. Thus the larger sizes, grades 1, 2, and 3, were required for spark plugs for the Aircraft Production Board for use in Liberty motors; grade 4 was required chiefly for radio condensers for both Navy and Signal Corps radio apparatus; grade 5 was used for magneto condensers for the motor transport service; and the smallest size, grade 6, was also used for spark plugs.

[1] The remaining portion of this section is essentially a copy of the report of activities of the mica section to the director, chemicals division, War Industries Board, which was prepared by C. P. Storrs and D. A. Hall.

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Speculation in Brazilian mica resulted in a tendency for prices to rise to a point equal to or higher than the fixed prices on Indian mica of equal or similar grade. For this reason the Navy order was extended on July 29, 1918, to cover Brazilian mica, maintaining the English fixed prices as a basis for payment.

It was the intention throughout that the Navy should simply act as an intermediary between importers and manufacturers and should not use the authority granted by the commandeering order beyond what was necessary to procure and maintain a reasonable quantity of mica as an emergency reserve. For this reason it did not seem necessary to extend the Navy order to domestic mica. It was the intention of the Navy to maintain commandeering orders only until stable price conditions were restored.

An association of importers of mica was formed early in 1918, which at all times contributed its support to the measures undertaken by the Government.

No tangible results had come from the efforts of the mica section under Mr. Adams to increase the production of domestic mica from the established producing districts in spite of high prices and active demand. The idea, however, became current among domestic producers that the Government was in a position to use a much larger part of their output, in some cases even to the extent of financing their enterprises. Considerable pressure was brought to bear to obtain Government aid.

The reorganized section under the chemical division accordingly undertook a careful investigation of the domestic situation in order to determine to what extent, if any, the output of high-grade material might be increased; what means would be necessary to bring about such an increase; and what the chances were for utilizing for Government purposes a greater quantity of the existing output. To this end the domestic producers were invited to submit their ideas on these subjects in concrete form. At the suggestion of the mica section the Association of Southern Mica Miners and Manufacturers was formed at a meeting of producers and dealers in Asheville, on September 3, at which a representative of the section was present. This association was essentially a war-service committee through which problems arising from the industry could more readily be met. The conclusions arrived at were briefly as follows:

1. Any artificial stimulation either in the form of price fixing or financing of mica mines by the Government was not warranted, inasmuch as such action would result in the increased production of the inferior grades of mica, of which there was a plentiful supply, and would not result in a material increase in the quantity of the high-grade material such as was required for Government use.
2. That under existing conditions as to both price and manufacture there was little chance of utilizing a much larger proportion of domestic mica.
3. That the situation warranted assistance to domestic producers with regard to priorities and in retaining skilled labor for the production of mica, as well as in having returned to them as far as possible such labor as had been already drafted.
4. That new enterprises should be encouraged to the extent of giving advice as to the existing conditions and the best means of marketing the output.

The efforts of the mica section so far as the domestic situation was concerned were based on these conclusions. A list of companies to be placed on the preference list for labor priorities was compiled. Many letters were written in answer to requests for information

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on the part of prospective purchasers with regard to mica markets, and conferences were held with producers relative to the general situation.

A similar organization of mica producers in the New England States was begun, and it was planned to form eventually a third one covering the western States.

Statistics as to requirements, consumption, and production of mica were early found to be very incomplete. Stocks of imported mica, particularly of the higher grades, were fairly closely determined; but, because of constantly changing specifications and likewise of the variety of sizes and grades of mica involved, progress was made very slowly in obtaining an accurate statistical background for understanding the situation. It became apparent that a complete questionnaire to consumers and dealers was not feasible, and none was attempted. Estimates of requirements of Government contractors were used as the basis for a consideration of war demands. These were amplified by figures as to requirements furnished by the departments of the Army and by the Navy. Lieut. Storrs was at all times in close contact with importers, dealers, and Government contractors, and was thus able to anticipate their needs somewhat in spite of the fact that exact future requirements were not known.

Under the enlarged Army program it became apparent that an increased quantity of mica would be necessary. The situation, though not critical, was becoming increasingly serious when hostilities ceased. Lieut. Storrs was preparing to go to England in order to take up with the British Ministry of Munitions the question of additional allotments.

Questions regarding South American output received careful attention, as this field was providing important additions to our supply of high-grade mica. At one time it seemed evident that higher prices were being offered in Europe for Brazilian mica than were obtainable in this country under the existing Navy order, and steps were taken toward correcting this discrepancy through the inter-Allied purchasing commission in London.

By way of a general summary of results, it may be stated that the establishment of the reorganized mica section found the industry in a chaotic condition, caused largely by the attempt on the part of certain consumers to beat the market, by a threatened shortage of supply from abroad, and by lack of information as to requirements and specifications. A careful analysis of the situation disclosed that the shortage was not as acute as had been supposed. Price regulation and close attention to future supplies of high-grade material were necessary. The Navy order very effectively stabilized the whole situation, and, although not greatly stimulating importation from England, it did stimulate shipments from Brazil, with regard to both quantity and quality of material. Direct Government purchasing abroad, with its consequent effect upon the importing business, did not become necessary, and the cooperation of the importers was at all times cordial. At the same time Government contractors were assured of an equitable distribution of the available supplies to meet their immediate needs. Although the activities of the mica section with regard to the domestic situation did not result in a materially increased supply of mica, certain valuable

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results were obtained. Dissatisfaction of producers as to price and other conditions and the belief that they were being discriminated against were very largely dispelled, and their confidence and support were obtained. A clear understanding of the domestic situation made possible conclusions as to the extent to which the material could be counted on to fill war demands.

PRICES.

The prices paid for uncut domestic mica continued to increase throughout 1918 until December, when they dropped to about the prices prevalent in July. The prices paid for domestic mica in the South in 1918 as compared with the prices for similar mica in 1917 were 27 per cent higher for punch, 38 per cent higher for 1½ by 2 inches, 29 per cent higher for 2 by 2 inches, 18 per cent higher for 2 by 3 inches, 13 per cent higher for 3 by 3 inches, and 10 per cent higher for the larger sizes.

The average price per pound of sheet mica produced in 1918 was 45 cents, apparently less than for 1917, 1916, 1915, or 1914, but higher than for any other year. This apparent decrease was due in part to the form in which the figures of production of mica are reported. In previous years some producers reported only their cut mica, which naturally has a higher value than the uncut. For 1918 nearly all the producers reported their sheet mica in the form of uncut mica, which with its lower value would have a tendency to lower the average price considerably. An additional reason for the lower price is that greater effort was spent in 1918 in obtaining the smaller sizes of mica of good quality, as there was no urgent need for the much larger higher-priced sheets. The average price of $246 a short ton for all mica produced is the highest reported and reflected the general increase in the value of mica but was due also to the small production of the low-priced scrap mica. The price of this scrap mica, from $10 to $20 a ton, was the lowest reported since 1906.

The following table shows by years the variations in value and price of the mica marketed in the United States from 1900 to 1918:

Price and value of domestic mica marketed in the United States, 1900–1918.

Year.	Total value.	Average price per short ton of all mica mined.	Average price per pound of sheet mica.
1900	$147,960	$26	$0.20
1901	118,578	50	.27
1902	118,849	75	.22
1903	143,128	73	.19
1904	120,316	84	.16
1905	178,588	112	.17
1906	274,990	125	.18
1907	392,111	110	.33
1908	267,925	92	.24
1909	280,529	56	.13
1910	337,097	64	.11
1911	355,804	80	.17
1912	331,806	91	.33
1913	436,060	71	.21
1914	329,956	82	.50
1915	428,709	101	.68
1916	594,391	122	.61
1917	806,782	198	.59
1918	764,940	246	.45

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Average prices per pound paid in the South for rough-trimmed sheet mica of good quality, split and sorted to cut the sizes indicated, 1913–1918.

Size (in inches).	1913	1914	1915	1916	1917	1918
Punch	$0.035	$0.03	$0.04	$0.05	$0.055	$0.07
1½ by 2	.12	.10	.20	.30	.40	.55
2 by 2	.30	.25	.40	.55	.70	.90
2 by 3	.70	.65	.70	.90	1.10	1.30
3 by 3	1.15	1.00	1.00	1.35	1.55	1.75
3 by 4	1.35	1.20	1.25	1.70	1.85	2.05
3 by 5	1.70	1.50	1.50	1.95	2.15	2.45
4 by 6	2.25	2.00	2.10	2.85	3.10	3.45
6 by 6	3.00	2.70	2.80	3.50	3.80	3.90
6 by 8	4.00	3.60	3.50	5.00	4.70	6.00
8 by 10	6.00	5.40	5.20	7.50	7.50	8.00

The average fluctuations in prices of domestic sheet mica for the year 1918 are shown in the following table:

Average prices per pound of domestic trimmed sheet mica in 1918.

Size (in inches).	January.	May.	July.	November.	December.
Punch	$0.06	$0.07	$0.08	$0.09	$0.07
1½ by 2	.45	.45	.55	.65	.55
2 by 2	.75	.80	.95	1.00	.95
2 by 3	1.20	1.30	1.35	1.45	1.35
3 by 3	1.60	1.75	1.75	1.90	1.85
3 by 4	1.90	1.95	2.05	2.30	2.15
3 by 5	2.25	2.25	2.40	2.95	2.65
4 by 6	3.25	3.45	3.25	3.80	3.50
6 by 6	3.75	4.00	.....	.....	.....
6 by 8	4.85	6.35	6.50	.....	5.50
8 by 10	8.00	8.00	8.00	.....	7.50

The scarcity of Indian mica of good quality led to speculative prices in the spring of 1918, and the Government was compelled to fix the prices of such mica and later to apply the same prices to similar mica from Brazil in order to protect the manufacture of commodities for the Government. The Government fixed prices were based on the English fixed prices plus 60 per cent. These prices were advanced in the summer and again in the fall.

Average prices of Indian sheet mica in the United States, May, 1918, based on the English fixed prices, plus 60 per cent.

Grade.	Quality.				
	Clear.	Part stained.	Second quality, clear.	Second quality, part stained.	Second quality.
6	$0.77	$0.67	$0.58	$0.48	$0.45
5	1.92	1.76	1.70	1.60	1.47
4	3.46	2.75	2.70	2.50	2.11
3	4.62	4.22	4.03	3.84	2.98

The English fixed prices were in effect May 14, 1918. Shortly afterward the Indian mica was more thoroughly classified according to

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quality by the British Government, nine different varieties being recognized, and prices were fixed for all sizes.

Prices per pound of Indian mica in the United States, July, 1918, based on the English fixed prices effective in London in July, plus 60 per cent.

Grade.	Quality.								
	Clear Government standard.	Part stained, Government standard.	Second quality, clear.	Second quality, part stained.	Fair, stained.	Ordinary (rust and clay) stained.	Densely stained.	Black spotted.	Soft white.
6	$0.74	$0.59	$0.48	$0.42	$0.38	$0.35	$0.32	$0.29	$0.38
5	1.95	1.78	1.71	1.62	1.49	.98	.59	.48	.88
4	3.50	2.78	2.72	2.53	2.14	1.76	1.17	.88	1.46
3	4.67	4.29	4.10	3.89	3.01	2.34	1.95	1.36	2.34
2	6.22	5.25	5.06	4.86	4.10	3.31	2.62	2.14	3.31
1	6.82	5.84	5.74	5.55	5.06	4.67	3.50	2.91	4.08
A-1	7.79	6.82	6.62	6.42	6.03	5.65	4.10	3.50	4.48
Special	8.37	7.39	7.10	6.82	6.22	6.03	4.58	3.89	5.06
Extra special	8.96	8.18	7.79	7.39	7.01	6.62	5.06	4.67	5.84
Extra extra special	11.68	9.73	9.15	8.75	8.18	7.79	6.22	5.84	6.82

These prices were again advanced considerably in the fall, the following table showing the Government fixed prices, effective after October 1:

Prices per pound of Indian mica in the United States, October, 1918, based on the English fixed prices, effective in London, October 1, plus 60 per cent.

Grade.	Quality.							
	Clear Government standard.	Slightly stained, Government standard.	Second quality, clear and part stained.	Fair, stained.	Ordinary (rust and clay) stained.	Densely stained.	Spotted.	Soft white.
6	$0.96	$0.77	$0.67	$0.58	$0.38	$0.35	$0.29	$0.38
5½	1.65	1.33	1.14	.96	.58	.48	.42	.58
5	2.67	2.29	2.00	1.68	.96	.67	.67	.86
4	4.58	3.49	3.42	2.54	2.00	1.13	.96	1.52
3	6.45	5.47	4.70	3.42	2.77	1.90	1.42	2.29
2	8.13	7.15	6.26	4.64	3.81	2.58	2.19	3.25
1	9.09	7.63	6.48	5.65	4.77	3.42	2.86	4.00
A-1	10.16	8.29	7.06	6.48	5.52	4.00	3.42	4.38
Special	11.02	9.25	7.44	6.86	5.90	4.48	3.81	4.96
Extra special	11.70	10.19	8.38	7.54	6.48	4.96	4.58	5.71
Extra extra special	15.25	12.58	10.02	8.77	7.63	6.10	5.71	6.67

The increase in price of sheet mica from 1901 to 1918 can be seen from the following table representing the prices paid in London for clear Indian trimmed sheet mica. The prices, in part, represent the sales of certain lots of mica and are not strictly accurate in giving the average values for any one time, but they are sufficiently close to give a picture of the rapidly advancing prices of sheet mica. The prices at which this mica would be sold in the United States would be approximately 50 per cent higher.

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Prices paid in London for clear Indian mica, 1901–1918.

Grade.	1901	1908	January, 1911.	September, 1912.	July, 1914.	October 1, 1918.[a]
6	(b)	(b)	$0.10	$0.12	$0.12	$0.54
5	(b)	(b)	.24	.50	.57	1.55
4	$0.14	$0.78	.72	1.06	1.13	2.52
3	.32	1.08	1.08	1.44	1.88	3.78
2	.78	1.44	1.32	1.86	2.00	4.78
1	1.22	1.68	2.04	2.10	2.19	5.23
A-1	.....	2.55	.....	.....	.....	5.77
Special	.....	3.16	.....	.....	.....	6.34
Extra special	.....	4.86	.....	.....	.....	6.84

[a] The average of the prices of "clear Government standard" and of "slightly stained Government standard."
[b] Grades 5 and 6 were converted into splittings.

IMPORTS AND EXPORTS.[1]

IMPORTS.

The sheet mica, including splittings, imported for consumption in the United States during 1918, as reported by the Bureau of Foreign and Domestic Commerce, was valued at $1,539,482, the highest value recorded by the United States Geological Survey. In 1918 there were also imported 6 tons of ground mica, valued at $1,647.

During the war years imports of mica were received chiefly from England, Canada, India, Brazil, and Argentina. In addition, mica was received in the last six months of 1914 from Germany, China, Guatemala, and Cuba; in 1915 from the Netherlands, Germany, Norway, Guatemala, Japan, and Scotland; in 1916 from France and Scotland; in 1917 from Costa Rica, Guatemala, Mexico, Newfoundland, and Peru; and in 1918 from Guatemala, Japan, British South Africa, China, Mexico, and France. The country named is not necessarily the country of origin of the mica.

Mica imported for consumption in the United States, 1909–1918.

Year.	Sheet.				Ground.		Total.	
	Unmanufactured.[a]		Cut and splittings.[b]					
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Pounds.		*Pounds.*		*Pounds.*		*Pounds.*	
1909	1,678,482	$533,218	168,169	$85,595	.....	.....	1,846,651	$618,813
1910	1,424,618	460,694	536,905	263,831	(c)	$1,298	(c)	725,823
1911	1,087,644	346,477	241,124	155,686	(c)	3,389	(c)	505,552
1912	1,900,500	649,236	88,632	99,737	[d]343,824	6,611	(c)	755,584
1913	2,047,571	751,092	(c)	191,926	290,757	4,765	(c)	947,783
1914	360,888	168,591	(c)	456,805	404,848	4,088	(c)	629,484
1915	433,822	240,449	(c)	447,962	344,040	3,858	(c)	692,269
1916	703,832	421,856	(c)	646,080	362,000	3,420	(c)	1,071,356
1917	656,391	414,823	(c)	1,014,181	92,963	1,044	(c)	1,430,048
1918	741,429	658,576	(c)	880,906	11,587	1,647	(c)	1,541,129

[a] Essentially trimmed sheets.
[b] Includes the Madras square-shaped uncut sheets.
[c] Quantity not reported.
[d] Figures for quantity cover only last six months of 1912.
[1] The statistical information on imports and exports given in this report has been compiled, as in earlier reports, by J. A. Dorsey, of the United States Geological Survey, from data furnished by the Bureau of Foreign and Domestic Commerce, United States Department of Commerce.

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The import duty on mica as quoted from the tariff act of October 3, 1913, is as follows:

Mica, unmanufactured, valued at not above 15 cents per pound, 4 cents per pound; valued above 15 cents per pound, 25 per centum ad valorem; cut mica, mica splittings, built-up mica, disks, plates, and all manufactures of mica, or of which mica is the component material of chief value, 30 per centum ad valorem; ground mica, 15 per centum ad valorem.

The figures in the following table refer to mica brought to port of entry and not necessarily entered for consumption in the same year. These figures, therefore, are not comparable to those given in the table of mica imported for consumption.

Sources of imported mica, 1915–1918.

Country.	1915	1916	1917	1918
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
India, direct and through England	32	47	53	54
Canada	65	50	38	26
Brazil	1	3	6	15
Argentina	0	(a)	3	4
Miscellaneous	2	(a)	(a)	1
	100	100	100	100

[a] Less than 1 per cent.

EXPORTS.

In 1918 mica was exported to France, Italy, Portugal, Spain, England, Bermuda, British Honduras, Canada, Costa Rica, Guatemala, Honduras, Nicaragua, Panama, Mexico, Newfoundland, Salvador, British West Indies (Barbados, Jamaica, Trinidad, other), Cuba, Dutch West Indies, Dominican Republic, Argentina, Brazil, Chile, Colombia, Ecuador, British Guiana, Peru, Uruguay, China, Dutch East Indies, Japan, Australia, New Zealand, French Oceania, Philippine Islands, and British West Africa.

Mica exported from the United States, 1910–1918.

Year.	Unmanufactured.		Manufactured.	Total value.
	Quantity (pounds).	Value.	Value.	
1910				$20,543
1911	415,862	$15,649	$20,267	35,916
1912	356,601	14,936	25,876	40,812
1913	298,711	14,175	48,009	62,184
1914	467,451	23,145	27,751	50,896
1915	54,183	5,118	33,915	39,033
1916	63,168	4,544	74,127	78,671
1917	[a]11,771	3,073	71,412	74,485
1918	(b)	(b)	(b)	74,529

[a] For six months, January to June. [b] Not reported.

PROPERTIES.

Mica is unique among minerals in its combination of properties useful to the industries. No other mineral has such a combination

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of perfect cleavage, flexibility, elasticity, toughness, transparency, lack of color in thin sheets, nonconductivity of heat and electricity, and resistance to high temperature, to sudden change in temperature, and to decomposition. These properties make mica indispensable in the electrical trade, which consumes most of the sheet mica mined. The enormous expansion of the electrical industry has been furthered notably by the unique properties possessed by mica. These properties enabled mica to play a most essential part in the World War, for the development of wireless telegraphy, of automobile trucks, and of airplanes could have been accomplished only by the use of mica. The recent invention doing away with the need of large and high receiving and transmitting towers for wireless stations is dependent on the use of condensers in which mica is one of the essential components.

Mica possesses other properties than those mentioned which are utilized in the industries. The brilliancy of small mica scales makes this material of value in the decorative arts, and it has been extensively used as a filler of various goods, such as rubber, in the manufacture of patent roofing, and as a lubricant. Thin sheets have also been used as coverings for wounds. More detailed descriptions of the various uses of mica in its different forms is given under the heading " Uses " on page 663.

There are several distinct mineral species grouped together under the term mica, but only a few of them have sufficient commercial value to be mined extensively. Some species of the mica group are of scientific interest only, and some might become of commercial value if it were not that they occur in exceedingly small deposits. The present report refers only to mica that is used as such in the trade and that remains mica in its final application. The only two species, therefore, that are of concern here are muscovite, the ordinary potash mica, also known as white mica, and phlogopite, the magnesian or amber mica.

The different varieties of muscovite have the same chemical composition, but certain varieties have slightly different physical properties which make them specially adapted for particular uses. For example, the best Indian ruby mica is unexcelled for electric insulation, the much harder green mica from North Carolina is specially suitable for stove fronts, and the brown mica from parts of Georgia, on account of its flatness, makes specially fine diaphragm or phonograph mica.

Other micas were mined in the United States in 1918, namely, roscoelite, lepidolite, biotite, and mariposite. Roscoelite has been found only as minute scales and is of value not because of its physical properties but because it is a source of vanadium; hence it is discussed in the chapter on vanadium in Mineral Resources. Another mica mined for its chemical content and not for its physical properties is lepidolite, a compact, fine, scaly mica containing several per cent of lithium. This mica is therefore described in the chapter on lithium minerals in Mineral Resources.[1] Although lepidolite has not been found in sheets of commercial size in the United States, such sheets occur elsewhere and have been mined to a very small extent in

[1] The last Mineral Resources report on lithium minerals is that for 1916.

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Canada and more extensively in Australia.[1] Zinnwaldite, another mica, is mined in Europe for its lithium content, but no commercial deposits are known in the United States. Biotite is mined spasmodically in small quantities; no large sheets are obtained, and the mineral is used only in a ground form as a filler and, after ignition, as decorative material. Small quantities of mariposite, a fine-grained greenish mica, are used for ornamental objects and as a pigment in paint. Clinochlore, a micaceous-looking mineral but a member of the chlorite group and not of the mica group, is mined and in a ground form finds application in many of the uses of ground mica.

Mica is sometimes called isinglass. This word has a double meaning; in addition to being applied to mica, it stands for a gelatinous substance, resembling mica in some of its properties, made of the air bladders of certain fish. This substance is soluble in boiling water and burns readily, whereas mica is neither soluble nor combustible.

Cleavage.—Good sheet mica should split easily to perfectly even, smooth sheets, but peculiar irregularities in crystal structure are common to nearly all micas, rendering the cleavage surfaces irregular, striated, or wavy. Tangle-sheet or tangle-foot mica will not split evenly, and ruled mica, to which the names ribbon, wedge, A, hair lined, reeved, fishbone, herringbone, and horsetail are applied, has but little value as sheet mica. Mica which will rupture when cleaved is termed cross grained. Ruled mica, in which the ruling is due to the presence of inclined gliding planes, will also often break up into many small pieces. Wavy, buckled, or corrugated mica is likewise of no value for use as sheet mica.

Only a large deposit, very favorably located with regard to transportation and grinding mill, can be profitably worked solely as a source of scrap mica for grinding. Most mica mines must yield good sheet mica to make the mining profitable. Mica, to be of value as sheet, must yield a rectangle at least 1½ by 2 inches, which must split easily and evenly, be free from cracks, rulings, markings, and all fracture lines, and be reasonably free from inclusions or specks of foreign mineral matter. The size stated is the smallest rectangular size which is salable in the form of uncut sheet; the rough-trimmed mica sheet must be nearly twice as large to yield the rectangle stated. In order to be profitable a deposit must also contain some mica larger than 1½ by 2 inches, and at least a small quantity of the largest sizes of fine quality is almost essential to the successful development of many mica properties. If mica did not usually contain many inclusions of foreign matter and did not have so many physical imperfections, such as cracks, rulings, and holes, there would be no difficulty in obtaining all the mica needed. But, in proportion to the mica mined, there is only an exceedingly small percentage of sheet mica which when finally prepared is of the proper quality to be used in the industries.

Specks and stains.—"Specked" or "spotted" mica contains inclusions of dark materials, mostly some form of iron oxide. The black, brown, or red inclusions of iron oxide—the "specks"—are in some crystals arrayed in straight lines which are either parallel to

[1] A recent communication from the General Foch Mica Syndicate, Kalgoorlie, Australia, was accompanied by clear transparent sheets of lepidolite 5 inches long.

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or bisect the edges of the crystal. Specks may be so abundant that the mica is called "black mica," even if the mica itself is nearly colorless. True black mica is biotite or a phlogopite very rich in iron. The specks or spots are extremely thin scales or crystals of iron oxide, which lie between the laminae of the mica but do not penetrate the sheets. Although specked mica is much inferior to clear mica for electric insulation, it can be used in electrical apparatus in which the current has only a low voltage. "Clay-stained" mica owes its unsightly appearance to the introduction of clay and dirt from outside sources. This clay lies between the sheets and may be easily removed by splitting off the thin layer of mica carrying the stain. According to the quantity of specks and stains present, mica is classified as clear, slightly specked or stained, heavily specked or stained, and stained. There are no arbitrary limits to any of these classifications, and mica which may be called clear by one person may be called slightly stained by another. The British Government found it necessary in 1918, in order to fix a fair price on sheet mica, to establish nine different gradings for Indian mica—clear Government standard, slightly stained Government standard, second quality clear and part stained, fair stained, ordinary (rust and clay) stained, densely stained, soft white, spotted, and splittings.

Color.—Muscovite is called clear or white mica. Clear muscovite in thin sheets is almost colorless; in sheets more than one-sixteenth of an inch thick it is amber, yellow, green, yellowish brown, brownish red or "rum," dark red or "ruby" (a piece of the ruby Bengal (India) mica, half an inch thick, is a beautiful ruby-red), smoky, gray, or brown. Muscovite nearly as clear and colorless as window glass is said to have been obtained from Labrador.

Phlogopite in thin sheets is generally yellowish or brownish; in thicker sheets it is yellow, brown, black, or coppery. Three varieties of phlogopite are noted in the trade—clear, transparent soft amber (the most valuable), streaked amber, and opaque hard amber. Phlogopite finds some special uses in electrical insulation because it is slightly softer than muscovite and not so likely to split and crack. It is used as sheets and in built-up mica board, made from splittings. Canada is practically the only producer. Very small quantities have been sent to London, the center of the world's mica market, from Ceylon, Madagascar, South Africa, Japan, and South America.

To a certain extent the color has been used as a means of distinguishing mica from different localities but such a usage is obviously imcomplete and inaccurate. "Silvery white," "yellow," "dark red," or "ruby" applies to Bengal mica, but the term "ruby mica" is also used for mica from Nilgeris (Madras), Brazil, and the United States. "Brown" mica comes from Madras, the United States, German East Africa, and the Transvaal; "green" from Nellore (Madras), the United States, and German East Africa. "Amber" is Canadian phlogopite, and "African amber" is brown muscovite from German East Africa and from the Transvaal.

Hardness.—The differences in hardness shown by mica from different localities are not very great in a strictly mineralogic sense, but they are of importance in the industries, where a relatively very slight variation in hardness may have a considerable bearing on the use of a certain mica. The following scheme of hardness for mica

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has been proposed; it is obviously only relative and could no doubt be considerably improved. No. 1 is the softest and No. 7 the hardest.

1. Amber, Canadian.
   (*a*) Soft, clear, transparent.
   (*b*) Medium, hard, streaked.
   (*c*) Hard, opaque.
2. White, Indian.
3. Soft green, Madras.
4. Ruby, Indian.
5. Hard green and brown, Madras.
6. Green, brown, and yellow, East African.
7. Green, United States.

Other properties.—The physical properties that make mica of commercial value are developed to different degrees in the different kinds although the variations are only slight. Biotite is not nearly so elastic as muscovite, phlogopite is a little softer than muscovite, and lepidolite fuses at a much lower temperature than muscovite. Even muscovites from different localities have slight variations in hardness, elasticity, and electrical resistance. This variation is said to be related in part to the color of the micas. Green muscovite from the United States is said to be the hardest of all micas, and the Indian ruby mica, is said to have the greatest dielectric strength or electrical resistance.

Good sheet mica should be so flexible that a sheet a thousandth of an inch thick can readily be bent into a cylinder ¼ inch in diameter without showing any cracking.

Classification.—The standards of classification of sheet mica with regard to quality and to size differ not only in different countries but even in different parts of our own country. Although the classification applied to domestic mica is fairly uniform, the absence of quantitative limits in the description of quality makes it difficult to define exactly a certain lot of mica. Three grades are generally used—clear, slightly spotted or stained, and heavily spotted or stained. The term "clear" is often used for mica which is anything but clear. It is this loose use of the term which has prejudiced many dealers against domestic mica. Calling mica "clear" when it is full of specks and stains is certainly extending the word "clear" far beyond its true meaning.

The basis of size classification of rough-trimmed uncut mica in the United States depends on the dimensions of the clear and usable circle or rectangle which can be cut from the rough-trimmed piece of mica. Punch mica will not yield a clear rectangle as much as 1½ by 2 inches but should yield a round disk of usable mica 1½ inches in diameter if stained and 1¼ inches in diameter if clear. Circle mica will yield a somewhat larger circle and is considered as lying between punch and the smallest rectangular piece. Circle mica should contain a usable disk nearly 2 inches in diameter. The smallest rectangular uncut mica, is 1½ by 2 inches. The next size is 2 by 2 inches, followed by 2 by 3, 3 by 3, 3 by 4, 3 by 5, 4 by 6, 6 by 6, 6 by 8, 8 by 10, and larger. A piece of uncut, rough-trimmed mica, classified as 2 by 3, should be large enough to yield a clear and usable rectangle 2 by 3 inches, the actual dimensions of the piece of mica itself being much larger, often nearly double the dimensions given. The dimensions of a well-trimmed piece of mica should not in general

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be more than 1½ times the dimensions of the contained usable rectangle. A 2 by 3 trimmed mica sheet should therefore not measure much more than 3 by 4½ inches.

The Canadian amber mica is classified on a similar basis, namely, that of the contained usable rectangle, the sizes, which are somewhat different from those used for domestic mica, being 1 by 1, 1 by 2, 1 by 3, 2 by 3, 2 by 4, 3 by 5, 4 by 6, and 5 by 8. For both domestic and Canadian mica, each class includes the size mentioned and all larger sizes up to but not including the next size. The 2 by 2 size would therefore include mica containing from 4 up to but not including 6 (2 by 3) square inches. A piece yielding 5 square inches (2 by 2½) would be classed as 2 by 2.

The Indian classification does not use the size of the rectangle obtainable, but the area of usable mica in the sheet. To certain areas arbitrary grade numbers have been assigned. For example, grade 5 must contain from 3 to 5⅓ square inches of usable mica, but obviously there must also be set at least a minimum width to the usable part, as a piece measuring one-fourth inch by 16 inches would contain 4 square inches but would not be classed as grade 5. The limiting sizes of the rectangles, which a piece of mica graded on the Indian classification must contain, have therefore been established by convention. The following table shows the Indian scheme of grading. The approximate corresponding sizes used in the domestic classification are also added.

Grading of Indian mica.

Grade.	Areas of usable mica (in square inches) based on rectangular sizes.	Sizes of rectangles that can be cut (in inches).				Approximate corresponding domestic sizes (in inches).
		Width.		Length.		
		Minimum.	Maximum.	Minimum.	Maximum.	
6	Less than 3.					Punch.
5	3 to 5⅓	1	2	2	2½	2 by 2.
4	6 to 9⅓	1½	2½	2½	3	2 by 3. / 3 by 3.
3	10 to 14⅔	1½	3	3	4½	3 by 4.
2	15 to 23⅓	1½	3½	4½	6	3 by 5.
1	24 to 35⅓	3	5	5	7	4 by 6.
A-1	36 to 47⅔	4	6	7	9	5 by 8.
Special	48 to 59⅔					6 by 8.
Extra special	60 to 71⅓					8 by 8.
Extra extra special	72 and more.					8 by 10.

The differences in the properties of mica and in the uses to which mica of different sizes is put cause the mica to be prepared in a number of different forms, which are described in the following section.

Crystals of mica as mined are rough blocks, hexagonal in shape if complete, but more commonly in irregular shaped masses, showing one or more crystal sides. After being freed from adhering rock, the mica blocks are split into thin sheets, which are roughly trimmed around the edges by the fingers or a knife—"thumb trimmed" or "knife trimmed"—and then graded for size and quality. The proportion of finished sheet, ready for use, obtained from the rough blocks is small, rarely being as much as 10 per cent. The remainder, the waste, is scrap mica suitable only for grinding.

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Through the courtesy of four of the larger mica companies, enough detailed information has been furnished to the United States Geological Survey to enable it to calculate the percentages of sheet mica obtained. The total quantity of mica concerned is large enough to give the figures considerable value. They refer only to mica mined in the years 1916, 1917, and 1918, in North Carolina, Georgia, and Alabama, chiefly North Carolina. The total quantity of mica—all mined because of its sheet content, on which the computations are based—was about 2,500,000 pounds.

Percentage yield of mica mined by certain companies.

Uncut mica:		
Uncut sheet		9
1½ by 2	3	
2 by 2	2	
2 by 3	2	
3 by 3	1	
Large	1	
Uncut punch		26
Scrap		65
		100
Cut mica:		
Cut sheet		3
Condenser	1.2	
Electric	1.1	
Stove	.4	
Phonograph, etc	.1	
Splittings	.2	
Cut washers		8
Scrap		89
From trimming	65	
From cutting punch	18	
From cutting sheet	6	
		100

FORMS.

In the various stages of preparation or manufacture from the mine to final consumption mica appears in several forms representing different degrees of work or manufacture. These forms may be grouped under three general classes—mine run, sheet, and scrap. The mine run is the form in which the mica is obtained from the mine; it comes in rough blocks from which the adhering rock has been removed. These blocks do not always give an indication of the quality of the mica throughout the crystal and may contain much good sheet or may be so flawed as to be of value only as scrap for grinding. These mine-run blocks of mica are also called "books," and the terms "book mica" or "block mica," applied to domestic mica, are synonymous with "mine-run" or "run-of-mine" mica. The term "block mica" unfortunately has also been applied to imported sheet mica. Very little mine-run mica is sold as such in the South, but in parts of New Hampshire and in the West, particularly in South Dakota and in Idaho, much of the mica is sold by the miner as mine-run mica.

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When these blocks of mine-run mica are cleaved or split into thin sheets, about one-sixteenth of an inch in thickness, the mica is called "sheet." Several classifications are used for sheet mica, dependent on the extent and character of the trimming and the uses for which the mica is intended. In trimming the sheet mica the broken and flawed parts of the sheets, mostly near the border, are broken and cut away, leaving an irregular-shaped piece from which a regular pattern may be cut. Thumb-trimmed mica has the loose and imperfect parts broken off by the fingers alone; knife trimmed has additional imperfect parts cut away with a knife. "Rough trimmed" is an indefinite term, perhaps representing a stage in the preparation of mica intermediate between thumb trimmed and knife trimmed. Rough-trimmed mica is also termed "sheet mica." Further modifications are introduced by such terms as "close trimmed." Most of the domestic mica, when first sold, is rough trimmed or poorly knife trimmed. Sickle-trimmed mica is closely knife trimmed, the large knife used being called a sickle. It is the form in which the Indian and other foreign mica is first sold. Sickle-trimmed mica, also called "Indian trimmed," is much closer trimmed than domestic knife trimmed and rarely contains any mica with cracks or important flaws, whereas the domestic knife-trimmed material still contains many imperfections, although the most prominent have been cut off. Sickle-trimmed mica, although irregular in shape, approaches a rounded rectangle. Mica from Madras, India, is cut with a shear into roughly square patterns and is called "shear trimmed" or "Madras trimmed." In shear-trimmed mica the cut edges are normal to the cleavage plane, whereas in sickle-trimmed and knife-trimmed mica these edges are beveled. Foreign sheet mica is also called "plate" or "block." Sheet or split mica is also technically termed "uncut" or "unmanufactured."

Sheet mica is also classified according to the uses to which it is put. Condenser mica must be clear ruby, colorless, or greenish, must split easily and smoothly into films as thin as one-thousandth of an inch, must be free from cracks, holes, foreign substances, stains, spots, smoke, and sheets, and must be plane and smooth, free from waves, wrinkles, reeves, rulings, or knots. Uncut condenser mica to cut any particular size must not be larger than one and one-half times that size each way. Cut but not split condenser mica is cut into regular sizes, 2 by 2 or 2 by 3 inches, which are slightly larger than the thin sheet actually used in the condensers. From this cut mica the condenser film is then punched out in the shape and size used. If cut and split, the individual pieces are from 0.001 to 0.003 inch thick, with an allowable variation of only 0.0005 inch. If cut or punched into the required shape, split to the necessary thinness, and carefully inspected, the mica is called condenser film mica. The cut edges of the films must be smooth, and the finished film must of course be free from all defects and cracks. For wireless outfits each film must withstand 20,000 volts. For magneto condensers no such high-voltage resisting test has to be made, but each film must be free from cracks or other defects. Such "film mica" is very different from the thin splittings used in the manufacture of mica board. These irregular-shaped splittings are sometimes also called films. It has been estimated that on an average it takes from

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2 to 3 pounds of trimmed Indian or cut domestic mica (or double the quantity of uncut domestic mica) to yield 1,000 acceptable condenser films. By careful selection it has been possible to obtain a pound of cut films from 5 to 6 pounds of domestic uncut sheet mica.

Phonograph or diaphragm mica is also a variety of very high grade. It must be free from all imperfections, such as rulings and cracks and inclusions of other minerals, must split well and even, must be clear and transparent, and must also be flat, this last feature being an essential character of diaphragm mica.

Mica for lamp chimneys and canopies must be clear, split easily, and be very flexible. Indian mica is the best, and Brazilian mica is also good. Very little domestic mica can be used for this purpose.

For stove fronts a nearly clear mica, hard and rigid, is most desirable, and much of the North Carolina mica, especially the greenish, is well adapted for this use.

The finest, clearest, and hardest mica is also called "bulkhead mica," although this term is not commonly used by the producer of domestic mica. It is of about the same quality as diaphragm mica. Mica that is essentially clear and has only a few spots or stains is called "stove mica." It is the ordinary variety of clear mica, although much mica that contains altogether too many imperfections is called "stove mica." A distinction is sometimes made as follows: Stove No. 1 is essentially "clear" and free from specks, but is not entirely free from air bubbles; stove No. 2 has some discoloration and a few black spots, enough to be called "slightly spotted." Electric mica is spotted or slightly stained, but not enough to prevent its use in general electric insulation. Spotted mica contains too many specks or inclusions of iron oxide to be suitable for high-voltage insulation.

Splittings are the very thin sheets or films of mica which are split from the smaller sheet mica. The excellent cleavage possessed by mica allows the material to be easily split into these thin films. The splittings are about one-thousandth of an inch thick, are irregular in shape and outline, and may contain a small quantity of flaws. They are so thin that a bunch of them feels like a mass of crumpled tissue paper. A small quantity of such splittings accumulates in the sheeting and trimming of the mine-run mica, but most of them are made by splitting up the smaller sheets of mica, especially the stained or spotted mica. In India, where most of the splittings are produced, the work is largely done by women and children. A delicate touch is required, and children make the best splitters. The mica sheets are split either with a small knife or with the thumb nail, which is purposely allowed to grow long. From 2 to 4 pounds of splittings a day is considered a good output. In Canada, where the splittings are made from amber mica, they are known as "thin-split mica." In the United States the domestic splittings are also called "slittings," "skimmings," or "films."

After the sheet mica has been all split into films of uniform thickness, they are reassembled into a large plate, being fastened together by means of an insulating cement under the application of heat and pressure. The thin films or splittings, in addition to being of uniform thickness, must have no thick edges or corners and must be free

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from all inclusions of hard mineral grains, so that the final built-up plate can be compressed to a uniform thickness. The splittings are laid irregularly one on the other either by hand or by specially devised machines. Shellac is the binder commonly used; it must be spread evenly and thinly over all the splittings; when the mica board is finally compressed and ready for use,[1] it should have uniform thickness and density, very low compressibility, and a binder or cement content of 3 to 5 per cent, preferably the lower figure, and should show almost no shrinkage, slipping, or oozing of cement. The standard size of the board is 18 by 36 inches. Muscovite and phlogopite or amber-mica splittings are both used, either separately or in various mixtures, to form boards with slightly different properties.

The built-up mica board is used chiefly for commutator segments and end rings and, in special shapes and sizes, either cut or molded, in dynamos, motors, and transformers.

The mica boards manufactured by different concerns have been given special trade names as follows:

"Micanite" is a term applied by the Mica Insulator Co., of Schenectady, N. Y., to a manufactured mica board or plate, built up by successive layers from many small thin films of mica, which, after being dipped into and cemented with shellac, are then subjected to pressure under heat to dry out the shellac. These large sheets are then milled to the requisite thickness and made suitable for many electrical purposes.

"Micabeston," which is similar to micanite, is manufactured by the American Mica Co., of Newton Lower Falls, Mass. Several varieties are made, one of which becomes flexible when heated and rigid when cold and is used for insulation in field coils, transformers, armatures, etc., where high heat is not generated; another variety remains rigid under a high heat and is used in commutators of generators and motors.

"Micabond," made by the Chicago Mica Co., of Valparaiso, Ind., is also similar and is made in varying qualities with different properties, depending on its use.

In these manufactured mica sheets a number of different substances are used as binders in addition to shellac, chiefly paper of various grades (Japan tissue, manila, rope, fish), muslin cloth, rubber, and gutta-percha.

The greater part of the domestic splittings consumed are purposely made directly from the uncut sheet. Domestic splittings also accumulate incidentally to the splitting of the mine-run blocks of mica into uncut sheet, and in the cutting of sheet into definite forms, as it is often necessary to skin a thin sheet of mica before cutting, so as to remove a particular stain or nest of specks.

The Canadian or amber splittings are either imported as such, being obtained in the same way as the domestic splittings, or else are manufactured in this country from imported uncut sheet. It is believed that the great bulk of the amber splittings consumed are imported as such.

[1] Much of the information here given is abstracted from a booklet, "The insulation of commutators," published by the Mica Insulator Co., 68 Church Street, New York.

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Some Indian splittings are manufactured in this country from the uncut sheet, and some accumulate in the cutting of the mica sheets, but nearly all the Indian splittings consumed are imported as such.

The waste mica resulting from the trimming and cutting of sheets, as well as the mica mined that does not contain any sheet of value, is called scrap and is suitable only for grinding. Scrap mica, as it comes to the grinding mill, is of various sizes and, unless formed exclusively from the waste of cutting, contains small inclusions of rock, chiefly quartz and feldspar. The scrap mica is ground into various sizes and sold as ground mica. A very coarsely ground mica used in wrapping tarred roofing paper is called "bran."

The forms of mica as described are summarized below.

- Mine-run.
- Sheet:
  - Uncut or unmanufactured:
    - Condition:
      - Thumb-trimmed.
      - Rough-trimmed.
      - Knife-trimmed.
      - Close-trimmed.
      - Sickle or Indian trimmed.
      - Shear or Madras trimmed.
    - Use:
      - Punch.
      - Condenser.
      - Stove.
      - Electric
      - Diaphragm.
  - Splittings:
    - Loose, as such.
    - Manufactured board.
    - Tape and other forms.
  - Cut or manufactured:
    - Washers.
    - Film or condenser.
    - Stove.
    - Electric.
    - Phonograph disks.
    - Manufactures of built-up mica board.
    - Other manufactures of splittings.
- Scrap:
  - Unground.
  - Ground.

Special trade names have been given to different forms of micas, as follows:

"Rimco" is mica ground by a nonmetallic process by the Richmond Mica Co., Richmond, Va., for use as a tire powder. It is also used by manufacturers of oils and lubricating greases.

"Micamima," prepared by the Crawford Mica Co., of Crawford, Nebr., is a coarsely ground mica used in the manufacture of concrete facing material; mixed with other minerals it is used to give the effect of natural rock, and it may be used for different decorative purposes.

"Micolith," or "micholithic," prepared by the Texas Mica Co., of Pecos, Tex., is another similar product used to give the effect of natural rock to concrete facings.

"Tungash," as the Denver Mining & Manufacturing Co., of Denver, Colo., calls its product, is a bronze-colored, metallic-looking material of value for decoration. The crude biotite mica, altered

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and hydrated, has a dull greenish-black appearance when mined. On being heated it expands to a light product, which has a rich golden-bronze color and a decidedly metallic luster.

"Silberglimmer" (silvery mica) is muscovite which has been heated to a sufficiently high temperature to make it softer and opaque and silvery in appearance. It is also known as annealed mica and finds a use in certain parts of electric apparatus.

"Clinomica" is the name given by the American Mica Co., 52 Broadway, New York, to its ground clinochlore, a micaceous mineral of the chlorite group. Clinomica possesses essentially the qualities of ground mica, and is used as a dusting material in the rubber and composition-roofing industries, for paints, cements, lubricants, molded electric insulation, and as a filler for various products.

USES.

The different uses to which mica is put depend on its form—whether in sheets or as ground mica. Sheet mica is used as an insulator in the electrical industry, for glazing, and to some extent for other purposes. Ground mica is used chiefly in patent roofing, in the decorative trades, for lubrication, as a filler, and for annealing.

Sheet mica finds its greatest use in the electrical industry, where an insulating, noninflammable, resistant material is necessary. In thin films it is used extensively in condensers for magnetos and wireless apparatus. It is used as an insulator in the form of sheets, washers, and tubes in dynamos and in numerous electric fittings and appliances, such as electric heating devices, electric-light sockets, spark plugs, insulators, guards in rheostats, fuse boxes, and telephones. Flexible cloth and tape, partly made of or covered with mica, find varied uses in electrical apparatus. Sheet mica is also used for glazing the fronts of stoves, for furnace sightholes, for screens in front of highly heated material, for optical lanterns as a retarder of heat waves, for making lamp chimneys and lamp shades, and for military lanterns. It is also used in special spectacles, in motor goggles, in sand blasting, in sightholes of diver's helmets and smoke helmets, in compass cards, in gage fronts, in windows where glass would be broken by heavy shocks or by vibrations, as in the conning towers of warships and of submarines, in lantern transparencies, and for mounting soft natural-history objects preserved in alcohol. Mica diaphragms are used extensively in phonographs and other sound-producing devices.

Large numbers of sheets of mica are used in India as the material on which pictures and portraits are painted, the mica being very durable, unaffected by heat or by dampness, and resistant to attacks of insects. Sheet mica is also used in India for ornamentation, such as inlaid work, for which a peculiar silvery mica is specially adapted, and for tassels, flowers, toys, and banners.

Sheet mica was an important and essential war mineral through its use as insulator in electric apparatus, especially in condensers, for magnetos and wireless apparatus, and for spark plugs; as windows and for other uses where a transparent, noninflammable, nonshattering material is necessary, as in automobile goggles; and as coverings for wounds.

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First-quality clear ruby mica had to be used in the manufacture of radio-condensers, magneto condensers, and spark plugs for airplane and automobile truck engines. A poorer quality was used for blocking the condensers and for general electric insulation.

Most mica splittings are consumed in the manufacture of built-up mica board used for general electric insulation, but the splittings also find application as such in making mica tubes for spark-plug cores and other insulating uses, wrappings for wire coils, and insulating tape.

Ground mica is used for decoration in wall paper, to which it gives luster and brightness; in fancy paints, ornamental tiles, and concrete. A mixture of ground mica and powdered aluminum is said to make a good rust-preventing paint, the ground mica being much cheaper than aluminum. The color and luster imparted by mica in certain paints may help to give a deceptive value to the object painted. Ground mica is useful because of its heat-resisting qualities, in the packings on railroad cars to prevent hot boxes, in pipe and boiler coverings, and in fireproof paints and coverings. Because of its heat-resisting qualities, it is used in making both solid and pneumatic rubber tires. It is also used by rubber manufacturers to preserve the rubber and as a finishing pigment. Ground mica is an essential component in some patent roofing material and is used in making molded mica (ground mica mixed with shellac) for electric insulation and in calico printing; as an absorbent for nitroglycerin in the manufacture of "mica powder"; in annealing steel; to a large extent as a lubricant for wooden bearings, or, mixed with oil, as a lubricant for metal bearings; in the manufacture of automobile treads on new tires, as well as in repair stock; in tire powder; as a filler for rubber goods; and for various other products. Tar and other roofing papers are coated with coarsely ground mica to prevent sticking when they are rolled for shipment. A possible value of ground mica as a chemical source of potash salts has been suggested, especially its direct application to the soil as a fertilizer.

In India ground mica is used for processional ornaments, such as lamps, pottery, curtains, cloth, and tinsel decorations on fans, and in buildings, especially in temples and palaces. It is also used for heat insulation in coverings for pipes and on roofs. Ground to a coarse powder and mixed with starch, it is so applied to cheap cotton cloths as to give them an attractive sheen. Large quantities have also been employed there for medicinal uses—an application which, fortunately, has not extended beyond its country of origin.

The percentages of different forms of mica consumed for different uses are given in the section headed "Consumption" on page 639.

The uses of mica may be summarized as follows, the classification being based on the physical property of greatest importance:

Electric insulation: Sheets, films, mica board, washers, mica cloth, and tape, for dynamos, condensers, telephones, light sockets, spark plugs, and innumerable other electric appliances. Ground mica mixed with shellac is molded into various insulating forms.

Heat insulation: Screens in front of highly heated material, as retarder of heat waves in optical lanterns, and in electric heating devices. Ground mica is used as pipe and boiler coverings, in annealing steel, and fire-proof paints and coverings.

Transparency: Glazing the fronts of stoves, for furnace sight holes, lamp chimneys, lamp shades, military lanterns, lantern slides, spectacles, sight holes

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of diver's helmets, compass cards, gage fronts, in windows where glass would be broken by heavy shocks or vibrations, and as coverings for wounds.

Resonance: Phonograph diaphragms and various sounding devices (submarine detectors).

Decoration: Sheets of mica form the material on which pictures and portraits are painted and for inlay work. Ground mica is used extensively for decoration in wall paper, processional ornaments, fancy paints, ornamental tiles, and concrete.

Lubrication: For wooden and metal bearings, tire powder.

Filler: Patent roofing material, rubber goods, buttons, absorbent for nitroglycerine, and various other products.

Miscellaneous: Calico printing, to prevent sticking of tar papers, medicinal uses (India only).

A recent classification of the uses of mica, based on their relative importance, is as follows:

Essential uses: Electric insulation—films, sheets, washers, splittings, and built-up mica board.

Less essential uses: Stove front, lamp chimney and shades, electric heating devices, pipe and boiler coverings, roofing material, annealing steel, lubricant for wooden bearings.

Nonessential uses: Phonograph diaphragms, decoration, lubricant for metal bearings, filler for rubber and various other materials.

SUBSTITUTES.

Some of the uses of mica are highly essential, others have developed more from the need of finding an outlet for those forms of mica whose production is incidental to the preparation of the leading commercial product, cut sheet mica.

It can not be said that ground mica has any essential use. For certain applications ground mica may be superior to other substances, but for every one of these applications—insulation, decoration, lubrication, annealing, coating, and filling—other materials can be and are used. As a few examples may be mentioned the substitution of asbestos in insulation, of chlorite schist in decoration, and of graphite in lubrication.

As given under the heading "Consumption," the uses to which uncut sheet mica (domestic and imported), including splittings, is put, average about as follows: For electric insulation, splittings 40 per cent and sheet 46 per cent, a total for electric insulation of 86 per cent; stove fronts, 10 per cent; phonograph diaphragms, 2 per cent; lamp chimneys, canopies, and all other uses, 2 per cent. Electric insulation covers a wide field and requires very different kinds of mica. The use of splittings in the manufacture of built-up mica board has reached a large development, the average annual consumption of splittings being greater than that of sheet mica.

There is no known successful substitute for mica splittings or for the manufactured built-up board made therefrom.

Attempted substitutes for mica have been of two kinds—either a compressed paper product specially treated, or bakelite, or a similar product. The compressed paper products are either oiled paper in very thin films, which may be built up into any desired thickness, or specially manufactured products, two of which have been given special names.

Micarta is an artificial mica product developed by the Westinghouse Electric & Manufacturing Co., of Pittsburgh, Pa., and is in-

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tended to take the place of hard fiber, glass, porcelain, hard rubber, built-up mica board, rawhide, molded compounds for use in commutators, bushings, brush-holder insulation, noiseless gear blanks, conduits for wiring, spools for spark coil and magnet windings, wireless-coil separators, and water-meter disks. Micarta is a tan-colored, hard, homogeneous material that can be sawed, milled, turned, and threaded. Thin sheets can be punched, and it is claimed that it will not warp, expand, or shrink beyond very small limits. Two grades of micarta are made. One, known as bakelite micarta, is infusible and will resist heat to a point at which carbonization of some of the ingredients takes place. It is insoluble in nearly all ordinary solvents, such as alcohol, benzine, turpentine, and weak acid and alkali solutions.

Pertinax is a product developed by Germany in consequence of its shortage of mica and was used specially for high-tension condensers. Part of the inefficiency of German airplanes has been ascribed to the use of pertinax in place of mica, often with disastrous results. Pertinax is a compressed-paper product which can be turned, stamped, sawn, cut, and drilled like wood. It will withstand high pressure, is not affected by hot oils, and begins to be destroyed only at about 200° C. Its puncture voltage is reported to be about 25,000 volts per millimeter.

Bakelite, a synthetic product made from carbolic acid and formaldehyde, is said to be a promising substitute for built-up mica board, especially as it may be poured into a piece of apparatus and thus molded right in place into the proper shape. But although the future may show some increase in the use of bakelite as a substitute for mica, at present mica splittings and their manufactured board have no satisfactory substitutes.

A product is also manufactured from kelp, which is hardened by treatment with formaline and can be pressed into any shape, turned, and highly polished. It possesses a high insulating quality, but obviously such material is not suitable for insulation where a thin film has to be used.

Oiled paper and compressed paper products are also used as substitutes for sheet and film mica, but only in certain places, and in general there is no satisfactory substitute for sheet mica used in electric insulation. As electric insulation accounts for 86 per cent of the sheet mica and splittings consumed and there is no satisfactory substitute known for them, it is evident that sheet mica must be considered an essential industrial mineral. For the remaining 14 per cent of applications of mica, substitutes can be used, for special kinds of glass will do for stove fronts and lamp chimneys, and many substances can be used for the reproducing diaphragm in phonographs.

FUTURE SUPPLIES OF MICA.

INTRODUCTION.

The future development of deposits of mica depends in part on the answer to the question as to whether or not the substitutes for mica will ever completely replace the natural mineral. So far as known there is no satisfactory substitute for sheet mica used in elec-

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tric insulation, which consumes 86 per cent of the sheet mica and splittings produced. During 1918 the need for sheet mica of good quality was very urgent and there was an unusual opportunity for the development of substitutes for it. The fact that none were found that satisfied the requirements indicated the improbability of any successful substitute being found for many years, if indeed any is ever found. The operator of any deposit of sheet mica therefore need not fear the competition of any artificial substitute, and with the growing applications of electricity, requiring insulation against ever-increasing voltages, the market for sheet mica of good quality must necessarily continuously increase.

Sheet mica of commercial value is found practically only in certain dike rocks known as pegmatites. Muscovite sheet mica is obtained only from quartz-feldspar pegmatite dikes, phlogopite at present entirely from the mica-calcite-pyroxene-apatite dikes, the true geologic genesis of which seems to be not entirely understood, but which are more or less intermediate in mineral character between pegmatite dikes and mineral veins. At a few places phlogopite sheets of commercial size are found in country rock such as serpentine and limestone, but all the commercial sheet mica is extracted from dikes. Muscovite can be used wherever phlogopite is used, although it is not so satisfactory for some uses, but phlogopite can replace muscovite in only a few of its applications. The following paragraphs refer almost exclusively to muscovite.

The necessary geologic conditions for the formation of sheet muscovite are the presence of numerous quartz-feldspar pegmatite dikes cutting metamorphic or crystalline rocks.

The geologic preservation of sheet mica demands the absence of folding and minute faulting, after the formation of the pegmatite dikes, for such movements would crumble and bend the mica sheets and render them worthless. Folding and faulting of mica-bearing rock develops in the mica sheets injurious properties such as ruling, which causes the sheets to break up into many small pieces, and wavy, buckled, corrugated, and other structures which prevent the easy splitting of the mica and leave the sheets with irregular, striated, wavy, or adhering surfaces. A deposit of such mica can not usually be profitably exploited, for the successful development of any mica deposit is generally dependent on its output of good clear sheet, as the scrap or mica suitable only for grinding—and this is all that ruled, buckled, and irregular mica is good for—is only an incidental by-product.

There are only a few regions where the earth's crust seems to be specially stable and to have withstood the folding and faulting earth movements for a long period of geologic time. The geologically old and stable peninsula of India, which has remained a firm solid mass since paleozoic time abutting against the crumpled and sheared Himalaya Mountains, the great stable mass of central and eastern Africa, and the American Piedmont, abutting against the Appalachian Mountains, are such regions. It is therefore obvious why commercially profitable deposits of sheet mica are extremely rare, although mica itself is one of the commonest of minerals, forming a part of nearly all rocks.

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To be commercially exploitable mica deposits must occur under favorable geologic conditions. Any deposits covered by alluvium, lava, or other rock formations would be effectually concealed from the prospector, for sheet mica underground can not be prospected for by drilling or by its effect on the magnetic needle. Other commercial features are of course of the greatest moment in affecting the success of any mica-mining project. Such features involve questions of labor, transportation, grading and packing, and market.

The chief producers of sheet mica are India and the United States (muscovite) and Canada (phlogopite). These three countries furnish about 98 per cent of the world's output. No country other than Canada produces any material quantity of phlogopite, but at several widely separated places outside of India and the United States deposits of fine sheets of muscovite occur and have been mined for several years. The most notable of these deposits are in the former German East Africa, Brazil, and Australia. The countries producing sheet mica may be placed in four groups according to their relative output. The first group, which absolutely dominates the mica situation to-day, comprises, as stated, India, the United States, and Canada. The second group includes those countries which have yielded small quantities of excellent sheet mica but are not sufficiently developed to show their potential productiveness, though they nevertheless suggest that in time they may become producers of great importance. This group includes German East Africa, Brazil, Australia, and possibly western Canada (British Columbia). Before 1900 their production was practically negligible. From 1906 (the first year for which figures of production are available for all the countries) to 1913, inclusive, their combined production amounted to 3 per cent of the world's output. For 1917 their combined output was estimated to be about 10 per cent of the total. The third group comprises the smaller producing countries, which have turned out some good mica for many years, but either they have not developed into important producers or else information about their mica deposits is so meager that their relative importance can not now be judged. The countries included in this group are Argentina, the Union of South Africa, Guatemala, Ceylon, and Madagascar. Perhaps the first two and possibly some others should be placed in the second group. The fourth and last group contains those countries from which sheet mica has been reported but which no longer produce it or about which definite knowledge of the quality and occurrence of the mica is lacking. These countries are Norway, Peru, Mexico, Russia, Chosen (Korea), China, and Japan.

Grouped according to continents, with their relative rank in importance, according to the four groups described, the sheet-mica producing countries are:

	Group.
North America:	
United States	1
Canada	1
Guatemala	3
Mexico	4
South America:	
Brazil	2
Argentina	3
Peru	4

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	Group.
Europe:	
Norway	4
Africa:	
German East Africa	2
Union of South Africa	3
Madagascar	3
Nyassaland Protectorate	3
Rhodesia	4
Protectorate of Southwest Africa	4
Kamerun	4
Asia:	
India	1
Ceylon	3
Chosen	4
Siberia	4
China	4
Japan	4
Australasia:	
Australia	2
New Zealand	4

Politically, the United States and Great Britain control essentially the entire output of sheet mica, the only mica-producing countries not under their sovereignty being Brazil and Argentina, whose combined output amounts to only a small percentage of the world's production. The United States and Great Britain are to-day the world's largest consumers, with France and Italy next. The leading European position in the electrical industry formerly held by Germany has been taken by England, which now has become one of the world's largest consumers of sheet mica. It is worthy of note that during the war Germany and her allies did not have access to a single sheet-mica producing locality.

In the following discussion it has been the aim to give such available information as to the character of the world's mica deposits, their production, and their geographic locality that something may be inferred as to the future relation of production to consumption. The countries are arranged under the continents in the order of their relative importance as mica producers. The order of arrangement of the continents is geographic—in fact, the order in which the countries are described is the same as that given above in tabular form.

NORTH AMERICA.

UNITED STATES.

The sheet mica produced in the United States is all muscovite. Sheets of clear phlogopite, used for stove fronts, were mined in northern New Jersey about 40 years ago, but there has been no recent production. Small quantities of scrap biotite and of scrap phlogopite, suitable only for grinding, are produced now and then. Compact granular lepidolite and roscoelite are mined annually, not because of their micaceous properties but chiefly because of their lithium and vanadium content, respectively. Clinochlore, a micaceous mineral resembling mica in some of its physical properties, is also mined.

Sheet mica comes annually from about 10 States, but commercial sheet mica has been obtained from at least 19 States, and occurrences

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of such mica are known in at least 6 more, so that altogether 25 States are known to contain sheet mica in varying quantity and of varying quality.

Mica-bearing pegmatites are generally associated with highly metamorphosed rocks of very great geologic age, such as schists and gneisses, although a few deposits occur in granite that has not been strongly metamorphosed. Most of the altered schists and gneisses containing mica-bearing pegmatites are of pre-Cambrian age. A study of a geologic map of the United States indicates the possibility of the occurrence of mica deposits in the following regions:[1] In the eastern Appalachian region from Alabama to New York State and in the New England States; in northern Wisconsin, Michigan, and Minnesota, and in the region including corners of Minnesota and Iowa and part of South Dakota; in the Black Hills of South Dakota; in the Rocky Mountain region from Texas to Montana; and in many smaller and more or less isolated areas in nearly all of the States west of the Rocky Mountains.

The States containing deposits of commercial sheet mica may be grouped geographically as follows. The States in which the deposits have not been successfully worked in recent years are indicated by an asterisk (*).

Southeastern States: North Carolina, Georgia, Virginia, South Carolina, Alabama.

Eastern States: * Maryland, * Pennsylvania, * New Jersey, * New York.

New England States: New Hampshire, * Maine, * Vermont, * Massachusetts, * Connecticut.

Western States: South Dakota, Idaho, * New Mexico, * Colorado, * Wyoming, * Texas, * Utah, *Arizona, * Nevada, * California, * Washington.

The important mica-producing States are North Carolina and New Hampshire; minor mica-producing States are Georgia, Virginia, South Carolina, Alabama, South Dakota, and Idaho. New Mexico and Texas are reported to contain mica deposits of considerable extent and value; the deposits in the remaining States are of problematic value.

The mica deposits of the United States have been described in detail in the annual reports on the production of mica, supplemented by several separate economic reports. The important papers are listed in the selected bibliography at the end of the present report.

The great demand for sheet mica of good quality for use in the manufacture of condensers naturally stimulated inquiry relative to the increased production of such mica in the United States. Because of unusual economic conditions, the contemplated increased production of mica was adversely influenced by other factors. For the country as a whole the production in 1918 was not much greater than that of previous years, Georgia being the only State to show an abnormally large increase in its production.

The southern mica field, including the western portion of North Carolina, with adjacent parts of Virginia, South Carolina, Georgia, and Alabama—a field producing about two-thirds of the domestic sheet mica—has always been handicapped because it is essentially an agricultural and not a mining region. Farmers do most of the mining, and in consequence there is at many places no continuous

[1] Sterrett, D. B., U. S. Geol. Survey Mineral Resources, 1914, pt. 2, p. 68, 1916.

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development of the mines. Many of the miners work their deposits on a very scanty capital and, not being used to mining on a large scale, cease operations because of such relatively unimportant and easily remedied conditions as the presence of ground water, lack of pumps or other machinery, caving in of tunnels and shafts, a slight decline in the price of mica, or depletion of a small lens of mica with consequent necessary dead work for a period. The mining of mica is exceptionally hazardous and often a good deal of dead work has to be done, especially if the mica occurs in lenses through the pegmatite. As a result there is a tendency to be ultraconservative, especially in newly opened regions. Another thing that has large influence in retarding the extension of mica mining throughout the South is the fact that the miners do not appreciate how much the salability of mica depends on its quality and on the size of the usable mica and not on the size of the material as mined.

These statements apply more to the numerous small prospects and the newer localities of the southern mica field than to the older established mines, some of which have been worked for many years. Other factors influencing adversely the development of some of the mines are the lack of cooperation, each owner or miner working independently instead of coordinating; the practice of "gophering" and of not timbering the shafts and tunnels, which makes the reopening of old mines extremely dangerous; the lack of stability of price, especially of the smaller sizes of mica, so that mines which do not yield large sheets could be profitably worked; and the effect of the importation of mica, chiefly from India, on the prices paid for the domestic mica.

Mica mining in New Hampshire is conducted under two additional difficulties produced by the cold winters and the hard, compact pegmatite rock carrying the mica. The mining operations in New Hampshire in 1918 produced some excellent mica, but that they were not eminently profitable is shown by the fact that in 1919 these operations have almost ceased. Undoubtedly a good deal of excellent sheet mica still remains in the New Hampshire mountains; whether this can be extracted profitably is uncertain.

South Dakota and Idaho and to a less extent New Mexico and Texas gave very disappointing results in 1918 in view of their supposed ability to produce good sheet mica. The lure of selling stock instead of the actual production of the mineral adversely influenced mica mining in some of these States.

CANADA.

The mica produced in Canada is phlogopite. Practically no muscovite mica is mined here, though several deposits have been worked in a small way in the past, and potential deposits of muscovite are reported to occur in the western part of the country. Small quantities of phlogopite have been produced from Ceylon, Madagascar, South Africa, and other countries, but Canada is commercially the only source of supply of this mica. The quality varies, as in all mica deposits, but excellent phlogopite is produced as well as inferior material.

The deposits lie chiefly in two well-defined areas in the Provinces of Quebec and Ontario. In Quebec the mica deposits now developed are

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immediately north of the city of Ottawa, in the county of Ottawa, bordering on and between Lievre and Gatineau rivers. The principal townships containing mica mines are Templeton, Wakefield, Hull, and Portland. The mica-bearing dikes extend westward into Pontiac County as far as the townships of Bryson and Waltham, and eastward into Montmorency and Wolfe counties, near Quebec. The northern extension is not known, but the total mica area is large. The mica deposits do not extend south of the city of Ottawa and may be said to be concentrated in the area between longitude 75° 30′ and 76° (about 30 miles) and latitude 45° 30′ and 45° 45′ (about 18 miles).

In the Province of Ontario the deposits lie in an area east of the Kingston & Pembroke Railroad, south of the Canadian Pacific Railway, and due north of the city of Kingston. The district extends from about longitude 76° 10′ to 76° 40′ and from latitude 44° 25′ to 44° 55′, and measures about 30 miles from north to south and 25 miles from east to west. It is in the counties of Frontenac, Lanark, and Leeds. In this district there are two main mica areas—that of Sydenham, in the south, in which the chief mines are in Loughborough and Bedford townships, and the Stanleyville, Micaville, or Perth area, to the north, in which the mines are chiefly in the townships of North and South Burgess and North Crosby. Deposits of phlogopite are known to occur outside of the area described. Mica has also been mined to a slight extent in Nova Scotia and in Newfoundland. From Newfoundland 12 barrels, valued at $243, was shipped in 1887, and nearly 26 tons, valued at $661, in 1899. These deposits, however, consist chiefly of scrap mica and have very little commercial value and no economic future.

Nearly all the phlogopite mined is sent to Ottawa, which lies between the two fields, for trimming, grading, and marketing, and most of it is exported thence to the United States.

The phlogopite mines of Canada are in dikes which cut limestone or gneiss and are composed essentially of a pyroxene, phlogopite, calcite, and apatite. The mica occurs either concentrated along one or both walls of the dike, in the dike itself, or in the neighboring country rock, or else it constitutes the principal mineral in concentrations or pockets in the dikes, either separated pockets or a line of such lenslike concentrations, lying in more or less well-defined shoots. At some places the calcite has been dissolved away, leaving cavities partly filled and lined chiefly with phlogopite crystals.

Many of these mica mines were originally opened for their phosphate content (apatite), and the mica was at first discarded. The utilization of the small irregular pieces of mica as splittings led to the working of many of the old mine dumps.

The geologic occurrence, character of the deposits, and methods of mining of the phlogopite mica in Canada have been so well described by De Schmid [1] that it is unnecessary to repeat the information here. As stated by him,

> The mica-bearing area is covered with small excavations, ranging from 2 to 10 feet in depth, all of which have been opened on small pockets of mica. * * * The extent of the distribution of the mica-bearing rocks

[1] De Schmid, H. S., Mica, its occurrence, exploitation, and uses: Canada Dept. Mines, Mines Branch, Rept. 118, 1912.

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throughout almost the entire region comprised between the Gatineau and Lievre rivers in the Province of Quebec, and also in the Perth-Sydenham area in the Province of Ontario, is such as to well justify one in assuming the existence of as valuable unexploited bodies of the mineral in these districts as have already been disclosed in the mines.

Few deposits have been exploited to a depth of over 200 feet, but in cases where this or a greater depth has been reached, indications of a continuance of the mica in depth have usually been found favorable.

Mica of considerable value was mined and shipped from Canada in the eighties, but it was not until 1906 that accurate information regarding the quantity of mica produced became available. For the period 1906 to 1917 the average annual production of mica was 714 short tons, with a minimum of 369 short tons in 1909 and a maximum of 1,208 short tons in 1916. The production of mica in Canada does not show any great annual fluctuation. The quantities reported, as given above, represent the returns published by the Canadian Government and include all kinds of mica from the sheet to the mine-run only roughly cobbed. It is impossible to give accurately the percentage of sheet mica (including splittings) represented by the reported production. In the table of world's production of sheet mica, already given, it was estimated that half of the reported production could be represented as sheet (that is, uncut sheet and splittings), although it is freely admitted that the estimate of half is only a guess, made in the absence of any exact information. If half of the reported production was sheet mica, Canadian phlogopite, for the period 1906 to 1917, constituted 11 per cent of the world's production of sheet mica, according to the table given on page 634. The average annual production of sheet mica in Canada for this period then amounted to 357 short tons.

An estimated itemized account of the preliminary figures of production of mica from the Province of Quebec for 1918 gives the following figures:

Mica produced in Quebec, 1918.

	Quantity (pounds).	Value (cents per pound).
Rough culled [a]	301,000	8
Thumb trimmed [b]	409,000	26
Split [c]	139,000	42
Scrap	57,000	1½

[a] Known as mine-run or run-of-mine mica in the United States.
[b] Known as rough-trimmed mica in the United States.
[c] Known as splittings in the United States, also called thin-split in Canada. Only the smallest sizes, not over 1 by 3 inches, are split for the manufacture of built-up mica board.

On the assumption that the rough-culled mica will yield, when split, from 10 to 30 per cent of sheet, there would be a total yield of sheet (including splittings) amounting to between 60 and 70 per cent of the total production. This is higher than the estimated 50 per cent yield of sheet, which admittedly is only an approximation but is preferred in the absence of fuller details.

In recent years, up to 1913, the quantity produced in Ontario was greater than that produced in Quebec, although its value was generally less. For the three years 1913, 1914, and 1915 the two Prov-

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inces produced almost exactly the same quantity, but beginning with 1916 Quebec has produced considerably more than Ontario, both in quantity and in value.

Of the mica exported from Canada for the period 1912 to 1916, 81 per cent went to the United States and 17 per cent to Great Britain. A comparison of the total exports with production, ostensibly giving the local consumption, is very likely to yield incorrect conclusions, as the mica exported is largely sheet and splittings and is therefore in a much more advanced stage of preparation than much of the mica counted as production. A consideration of the relative figures, however, strongly suggests that very little of the sheet mica mined in Canada is consumed in that country and that practically all of it is exported, a conclusion in agreement with other known conditions of the manfacturing industry of Canada.

Prices paid in Canada for the different sizes of sheeted or trimmed phlogopite average about as follows:

Prices per pound of phlogopite mica in Canada in 1910, 1916, and 1917.

Size (inches).	1910	1916	1917
1 by 1	$0.04	$0.06	$0.09
1 by 2	.09	.13	.14
1 by 3	.17	.18	.24
2 by 3	.43	.43	.45
2 by 4	.63	.65	.80
3 by 5	.80	.90	1.65
4 by 6	1.13	1.25	2.10
5 by 8	1.67	.....	2.50
Over 5 by 8	2.00	.....	.....

Muscovite in large and clear sheets has been reported from numerous places in the Province of Quebec, especially in the Saguenay district, on lower St. Lawrence River below Quebec, and in the counties of Ottawa and Berthier. Isolated deposits are also found in the Province of Ontario. The available information on these muscovite localities is given by De Schmid. Most of these deposits were soon abandoned, and there has been no recent production of muscovite in Canada, the more lucrative phlogopite monopolizing the mica miners.

Good muscovite mica is known to occur also near Tete Jaune, in British Columbia. The mica is clear and has a very light greenish tint and seems to be of excellent quality. Especially large clear sheets are said to have been obtained here, cut sheets measuring 18 by 11 inches being reported. Sheets of mica, as found, are said to be abundant in sizes a foot square and sheets 2 by 3 feet were encountered. The mica cleaves well and is partly clear, though some of it is considerably spotted with iron oxide. It is claimed that out of a lot of 2 tons extracted in 1914, half could be trimmed into sheets 2 by 5 inches. Tete Jaune is in the southeastern part of Cariboo County, about 35 miles west of Yellowhead Pass through the Rocky Mountains, on the Grand Trunk Pacific Railway, and about 120 miles north of Revelstoke, on the Canadian Pacific Railway. The mica-bearing pegmatites, as much as 50 feet in width, are high up on the mountains, at 5,000 to 7,000 feet above the sea, on the

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south bank of Fraser River. The outcrops extend for many miles, from a point below Tete Jaune to Albreda Summit, near Canoe River. The production has been small; the total quantity sold has amounted to only a few tons, consisting of small lots taken out during the last 20 years. The entire field is still in a preliminary stage of development, but it seems to warrant careful investigation, according to several reports, and unless transportation difficulties should be too severe, it may develop into a future producing area Transportation, however, seems to be an important factor, as all supplies have to be carried for many miles by pack trains over bad trails. The country rock is said to consist of mica schists and gneisses. The winters are very severe, and all transportation has to be done during the summer.

GUATEMALA.

A mica zone is known to occur near the center of Guatemala, north of Guatemala City. The mica outcrops are in the States of Baja Verapaz and Quiche. The outcrops in Quiche are near the boundary with Baja Verapaz but apparently have not been worked on a commercial scale. In Baja Verapaz deposits at two localities have been exploited, the high price of mica having stimulated prospecting and development work. The pioneer in mica development work in Guatemala was the Guatemala Mining & Development Co., an American firm, which about 10 years ago spent considerable money in the exploitation and development of mica properties in Quiche and Baja Verapaz. This company ceased active operations after mining only a small quantity of the mineral. Sarecky & Chellis, American operators, are to-day the principal shippers of mica from Guatemala. A number of small prospectors are endeavoring to develop mica properties, but owing to the difficulty of procuring satisfactory and trustworthy labor, to the occurrence of the mica in hard rock, which has to be blasted, causing much waste and ruining the larger sheets through the development of hair cracks, and to the lack of explosives, the importation of which is prohibited, except under special permit of the Guatemalan Government, the operators have not yet been able to produce mica in large quantity. Muscovite from a deposit near Chol, Baja Verapaz, ranges in color from white to rum and has been shipped in sizes from 2 by 2 inches to 10 by 12 inches. A deposit of greenish muscovite near Salama, Baja Verapaz, has been exploited, and the product shipped.

Surface mining of mica in Guatemala, owing to the large incidental waste, costs about 25 cents a pound; the mica must be transported from the mines to the nearest railroad station (Guatemala City) by mules, which are scarce and expensive; the cost of railroad transportation to Puerto Barrios is $24 a ton; and the cost of ocean transportation from Puerto Barrios to New York is about $20 a ton.

Several shipments of the greenish mica from Guatemala were tested by the consumers of sheet mica for use in the manufacture of high-tension condensers, with general unsatisfactory results. So much of the mica as received is flawed that it takes from four to six times the quantity of Guatemala mica, as compared with other mica, to yield the same quantity of cut mica. With the Guatemala mica

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bidding for about the same market price it obviously finds very little sale. Another objection to this mica lies in the fact that it does not split freely and evenly and therefore does not lend itself readily to the preparation of the very thin films of mica required in condenser work. It may be, however, that the mica would be more suitable for glazing, as in the fronts of stoves, and for general electric insulation where no high potentials are used.

MEXICO.

A dark amber-colored phlogopite mica has been obtained from a deposit near Guadalajara, Mexico. The associated rock is said to be limestone, but it is not known whether the mica occurs in limestone or in calcite veins, such as are found in Canada. Small lots have been sent to the United States, but it is not thought that the locality will produce much mica of value. Mica in sheets 6 by 6 inches was also reported in 1898 to have been found near Villa Corona, Durango, about 40 miles from the railroad.

SOUTH AMERICA.

BRAZIL.

Muscovite of excellent quality has been found in Brazil in the contiguous States of Bahia, Goyaz, Minas Geraes, and Sao Paulo. Minas Geraes contains especially valuable deposits in the neighborhood of the city of Santa Luzia de Carangola, on the Leopoldina Railway; near Pecanha; northeast of Itabira de Matto Dentro; near Bicas; at Villa Rio Piracicaba; and near Sao Domingos do Rio do Peixe, in the municipality of Conceiçao. The mica is exported from Rio de Janeiro. The most valuable deposits in the State of Goyaz are found in the municipality of Meia Ponte. In Sao Paulo deposits of mica have been discovered on Bananal, Itapecerica, Parnahyba, Sao Bernardo, and Juquie. The mines at Juquie, in the neighborhood of Itapecerica, are mostly near the Government railway between Itapecerica and Prainha, in the neighborhood of Iguape, at the point where the railway crosses Juquie River. There are large mines on the right side of Braco Grande River, 11 miles south of the village of Juquitiba. In Bahia the mica deposits are between Jacobina and Villa Nova, in the valley of Itapecuru River, and near Paulo Affonso Falls.

The producing mines are in pegmatite dikes and lenses as much as 20 feet wide, which occur in the metamorphic schists that form the country rock. The pegmatites are greatly decomposed, the feldspar being altered to kaolin to a considerable depth. The mica crystals are irregularly disseminated through this soft kaolinized feldspar. The adjacent metamorphic schists are also greatly decomposed at many places.

Much of the mica mined is excellent in quality and very similar in both quality and texture to the Indian ruby mica. The mica crystals measure as much as 20 by 10 inches across and 6 inches thick, and an average size for the crystals is about 6 by 6 inches and 3 inches thick. A considerable quantity of the mica crystals are soft and

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decomposed, but others are firm and hard. The Brazilian mica, as mined, after the worthless material has been rejected, produces about 10 per cent of knife-trimmed sheet, which, if carefully trimmed, yields an average of about 50 per cent of cut sheet.

It is stated that the Brazilian mica industry should prove to be very lucrative, for properly prepared, the mica is well thought of in foreign markets. Considerable capital has been invested in the industry, and special attention has been given to the preparation, classification, and packing of the mica to meet the requirements of the foreign purchasers. Some of the difficulties in the development of this industry are lack of transportation facilities to the distributing centers and ports of departure, scarce and inefficient labor, and excessive rains and fever.

The production of sheet mica in Brazil was relatively small before the war. For the period 1902 to 1913 the total production was about 116 short tons, or an annual average of not quite 10 tons. The value of this mica was estimated at $300 to $400 a ton. In relation to the world's production, Brazil produced in the period 1902 to 1913 about one-third of 1 per cent. For 1914 Brazil's production of mica amounted to 17 short tons, of an average value of $836 a ton. Since then both the quantity produced and its value have increased considerably, 59 tons for 1916, 106 tons for 1917, and an estimated production of 125 tons for 1918. The mica in 1916 had an average value of $921 a ton and in 1917 of $1,245 a ton, or more than 50 cents a pound, a good indication of the real value of Brazilian mica when properly selected, trimmed, and sorted. For 1917 the quantity of mica produced in Brazil amounted to nearly 3 per cent of the world's production, an increase of 10 times the relative production before the war.

ARGENTINA.

The mica shipped from Argentina to the United States is muscovite. So much of this mica was spotted and stained that Argentine mica was becoming known as stained mica, but recent shipments have included good clear mica, and it is possible that further development will show that Argentina can produce a considerable quantity of that grade. One reason advanced for the former preponderance of stained mica in the material exported was that most of the clear mica was consumed locally in the electrical industries, although the quantity so used probably does not exceed 1 or 2 tons a month, and the export figures probably closely approximate the total production.

The deposits are said to be numerous and to lie especially in the Provinces of Cordoba and San Luis. These Provinces are in the west-central part of the country, about midway between Buenos Aires and Valparaiso, Chile. The Province of Cordoba is traversed by several railroads.

The La Realidad mine, about 7 miles northwest of La Toma and south of Cienaga del Intiguasi, on the eastern slopes of Cerros del Rosario, San Luis, and a group of mines near Calamuchita, Cordoba, have shipped good sheet mica. That from Calamuchita is light brown. Other localities in the mountainous parts of Cordoba are Champagui, in Sierra del Alto, Alta Gracia, and Santa Maria. In the Province of San Luis mica has also been mined at Paso del

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Totoral, Victoria Morada; in the Province of San Juan on the Usno farm, north of Valle Fertil, in the Sierra de la Huerta; in the Province of Tucuman at Monteros; in the Province of Catamarca near Tinogasta; and in the Province of La Rioja near Villa Union.

Altogether about 200 mica deposits have been opened, but only about a quarter of these were worked. The producing mines are all in the Provinces of Cordoba and San Luis, although mica of commercial value has also been reported from the Provinces of San Juan, Catamarca, and Salta.

The exploitation of the mica mines is only an incidental operation and does not constitute an established industry, being carried on in a small way by numerous private individuals. The mica is sold in the crude state to local buyers, who prepare it for sale to the exporters. Skilled labor for working the mines and properly trimming and sorting the sheets of mica seems to be scarce, but this difficulty can probably be overcome, as experience is gained with the continued exploitation of the deposits. Prices advanced materially in 1918 in Argentina, owing in part to the fact that several German companies were buying and holding mica so as to prevent its export to the Allies.

The first year of record for production of mica in Argentina is 1908, when about 1 ton was produced. The output increased with succeeding years and amounted to 21 tons in 1910, but it then decreased until in 1915 it was reported that there was no production. In the years since 1915 the production has rapidly increased, amounting to 70 tons in 1917 and to an estimated production of 80 tons in 1918. The average annual production for the period 1908 to 1913 was about 10 short tons. For the period 1914 to 1916 it was only about 3 tons, but in 1917 and 1918 the production amounted to about 2 per cent of the world's production. The destination of the mica exported in 1917 was as follows: England, 71,012 pounds; United States, 52,470 pounds; Italy, 12,099 pounds; Spain, 2,809 pounds.

PERU.

Sheets of mica 9 inches square have been found on a pegmatite dike some distance north of Mollendo (port of Arequipa), Peru. Most of the mica, however, was small, not more than 4 inches square. Several hundred pounds of mica is reported to have been exported annually from Peru to the United States in the last few years.

EUROPE.

NORWAY.

The Godfjeld mine, near Skutterud, on the southwestern coast of Norway, has been developed on a pegmatite dike nearly 100 feet thick. The mica crystals are mostly small, but plates measuring 1 by 2 feet have been found. The mica is greenish, but the many stains and mineral inclusions give it a brown appearance. The books of mica are intergrown and wedge shaped, so that the cleaved pieces do not have parallel surfaces. At a depth of about 60 feet the mica was found to be soft and brittle and was described as being rotten and

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altered to some much softer material. The mica occurred in shoots or lenses in the pegmatite, and excavations were carried down to 100 feet. There was no production of mica from Norway for many years before the war; but it is reported that mining was feverishly renewed toward the end of the war and that some of the mica obtained was sold to Germany for $70 a pound. It is worthy of note that this occurrence in Norway is the only deposit of sheet mica to which Germany had access after her intercourse with Africa was stopped.

AFRICA.

GERMAN EAST AFRICA.

The mica from the former German East Africa is an excellent dark-green or brown muscovite, splitting very easily into smooth, flat sheets, and unusually free from imperfections in structure and from inclusions of foreign mineral matter. Many of the mica sheets are clear and transparent in half-inch thicknesses. The mica crystals are large, some of them 3 by 3 feet in the rough state and yielding trimmed sheets measuring nearly 18 inches across. Phlogopite was found on Ssuwi River, but, although some good sheets having a golden sheen were obtained, most of the mica mined here was too much folded and cracked to be of commercial value.

The mica deposits are scattered over the eastern and southern part of the country, the most valuable group, centering in the Uluguru Mountains, being located at about 7° latitude and 38° longitude. The known deposits may be placed for convenience in six groups, as follows:

Mica localities in German East Africa.

Locality.	District.	Longitude (east).	Latitude (south).
Uluguru Mountains	Morogoro	38°	7°
Do	Mbakana River	37½°	7½°
Do	Nguru Mountains	38°	6½°
Usambara	Mombo	38°	5°
Do	Schuerffeld Roland	38½°	4½°
Mahenge	Tangiro	36°	9°
Lindi	Mawa	39°	11°
Do	Muera	39°	10°
Woto		34½°	9½°
Pongive Mountains	Ssuwi River	38½°	6½°

The Uluguru Mountains contain the most valuable mica deposits of German East Africa. The deposits are grouped around three distinct places: (1) those in the Morogoro district, in the north end of the Uluguru Mountains; (2) those on Mbakana River, in the southern part of the range; (3) those near Mkondami, in the Nguru Mountains, the northern extension of the Uluguru Mountains. Some of the localities in the Morogoro district, chiefly Mhindu, Nguru, Kigambue, and Mssassa, north of Morogoro, contain very many nearly vertical pegmatite dikes, 15 to 20 feet thick, cutting the country rock, which is chiefly biotite gneiss and mica schist. The dikes trend east. Large bodies of massive quartz are abundant, especially in the center of the dikes. The very abundant mica lies

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between the quartz and the outer zone of granular pegmatite, feldspar being the other component mineral. The mica zone attains a width of 5 feet. The dark-brown transparent mica sheets are abundant in sizes as much as 18 inches across. The deposits on Mbakana River, a tributary of Mgeta River, are also very valuable. Excellent mica of a greenish or brownish color, in transparent sheets free from fractures and mineral inclusions, has been abundantly obtained from the numerous nearly vertical pegmatite dikes cutting the predominant biotite gneiss. The dikes have a miximum thickness of 70 feet and contain much massive quartz, on the edges of which is abundant mica. The mica zone attains a thickness of 15 feet. The pegmatites are not much decomposed, and bent or cracked mica sheets are rare. Crystals measuring 35 by 31 inches have yielded trimmed sheets, free from flaws, measuring 18 by 15 inches. The largest crystals found are 3 feet across and nearly 1 foot thick. Crystals measuring about a foot across are very common.

In Usambara, near the border of British East Africa, excellent mica has been found in the many pegmatites cutting the gneissic country rock. At Neu Hoeffinghoff, slightly north of Mombo, pegmative dikes, striking northwest and as much as 30 feet thick, have yielded excellent mica of a smoky brown color as well as crystals of a very light color. The pegmatites average about 5 feet in thickness, with massive quartz in the middle and feldspar and mica on the edges. Many lenslike concentrations of mica are encountered; other minerals in the pegmatite are tourmaline and garnets in large crystals. The mica plates attain a size of 4 by 1½ feet and trim into large, clear sheets. Northeast of Mombo and about 10 miles northeast of Wilhelmsthal (about halfway from Mombo to the border of British East Africa), at Schuerffeld Roland, smoky brown sheets of mica, with some magnetite inclusions, have been obtained from pegmatites. The mica sheets split easily, are very flexible, and measure several feet across. In the Mahenge district good sheet mica has been obtained at Mount Fissage and near Tangiro; other localities are at Mawa and Muera, in the Lindi hinterland, in the southeastern corner of the country; and in the Woto plateau, in the Langenberg district, in the southwestern part of the country, near the north end of Lake Nyassa.

All the localities mentioned yield only muscovite, but on the Ssuwi Stream, which flows down the northern slopes of the Pongive Mountrains, a few miles west of Bagamoyo, there is an area of strongly weathered augite rock (pyroxenite?), measuring about 600 by 360 feet, which has yielded thick plates of phlogopite mica, occurring in nests and associated with apatite, calcite, magnetite, ilmenite, and tourmaline. Graphic granite pegmatites also occur here, the country rock being a gneiss. Excavation to a depth of 12 feet yielded some good sheets of mica, although most of it is considerably folded and cracked.

Practically all the deposits, which were first opened about 1902, are small excavations of the open-quarry type. One of the drawbacks formerly existing was the very cheap license fee (2 cents per claim for the first year and 12 cents per claim for the second year) under which claims could be held on speculation without being worked. This hindrance seems to have been removed, and mining

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has been actively developed, especially since about 1908, after which more than 100 tons of choice trimmed mica was produced annually. Transportation seems to have been one of the main difficulties, as the country around the mica mines has been only partly opened. The deposits, however, are not for from the seacoast and lie almost directly west of Dar-es-Salam, and with an assurance of steady production the transportation problem would be readily settled. It is stated that the mines have been worked by the British military authorities and that before their seizure they were yielding mica at the rate of nearly 1,000 tons a year. A concession of exclusive rights to exploit mica deposits in Concelho de Lago was recently granted by the Government of Portuguese East Africa, but it is not known whether the deposits lie in that country or the adjoining German East Africa.

The output of German East Africa in relation to the world's production in 1906, the first year for which a comparison can be made, amounted to about three-fourths of 1 per cent. For the period 1907 to 1913, it amounted to 3.4 per cent, and for 1913, the last year for which authentic figures are available, it amounted to 4.3 per cent, showing a steady increase. From informal reports it seems as if the production during the war had increased very much. From 1902 to 1907 the average annual production was 21 short tons; from 1908 to 1913 the average was 127 short tons.

After India, the United States, and Canada, German East Africa is the largest producer of sheet mica and holds forth the most promising future. It would thus rank third in actual value of output of muscovite mica in the world.

UNION OF SOUTH AFRICA.

The important mica deposits, all muscovite, in the Union of South Africa are in the Transvaal. Other Provinces of the Union known to contain commercial sheet mica are Natal and Cape of Good Hope (Cape Colony). The Transvaal deposits are in the Leydsdorp division of the Pietersburg district, a well-defined mica belt 50 miles long and from 2 to 4 miles wide extending along Olifant River, southeast of Leydsdorp, from a point near Mica siding, on the Leydsdorp Railway, eastward toward Portuguese East Africa. Operations have been limited to three areas—(1) near Mica siding, 22 miles east-southeast of Leydsdorp; (2) about 25 miles east of Mica siding (Union mica mines); and (3) 75 miles east of Leydsdorp, near the junction of Malelane and Olifant rivers (the Malelane mica fields).

The muscovite from the Transvaal, the only Province yielding a fairly constant production, is mostly of a pale-brown color, but that from the Malelane field has a pale-green tint. The mica books or crystals are usually very large, the largest being 5 feet across and 1 foot thick. Much of the mica is spotted and defective, although clear brown mica, cleaving freely, is found in the large crystals. Many of the books are spoiled by the presence of vertical cracks or inclined gliding planes which pass right through them. Other crystals are buckled and present a wavy surface, and in still others the cleavage plates are of uneven thickness.

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The mica varies considerably in quality. A small proportion of the mica books contain beautifully clear brownish muscovite, free from flaws and of excellent splitting quality, but many of them have a spotted or mottled appearance, owing to the presence between the laminae of numerous inclusions of deep-brown or blackish-brown color. These inclusions are frequently arranged in lines cutting one another at angles of 60°. The nature of these inclusions has not been determined, but careful tests have shown that their presence does not materially impair the electrical resistance of the mica. The green mica occurring at Malelane has a greasy feel, is somewhat soft, and seems to be of exceptional quality.

The clear brownish muscovite of the Leydsdorp fields has been proved to be equal to the best grades of Indian and Canadian mica in dielectric strength. It is slightly harder than Canadian phlogopite and certain varieties of Indian muscovite and therefore not quite so well adapted to armature work. The greenish mica from Malelane appears to be softer, and it is very desirable that its suitability for this purpose be practically tested.

The mica occurs in conspicuous dikes of coarse white pegmatite, with a prevalent easterly trend, following the southern margin of a great elongated batholith of newer granite—the so-called Palabora granite—intrusive in the older granite, gneiss, and schists of the Swaziland system. The dikes, which are very numerous, are several hundred yards in maximum length and 40 feet or more across. They present the usual characteristics of pegmatite, being subject to abrupt variations in width and taking unexpected twists and turns. The pegmatite is composed essentially of quartz, albite, and mica, which in some localities, notably at Malelane, are accompanied by fluorapatite, garnet, and tourmaline. Here, as in other parts of the world, the distribution of the larger plates and crystals of mica through the pegmatite is very sparse and sporadic, the best books being generally aggregated in irregular pockets or in vertical or highly inclined leads resembling the ore shoots of mineral veins. Some pegmatite dikes are much richer than others, but the average proportion of merchantable mica is probably not more than a few hundredths of 1 per cent of the total dike rock.

Most of the workings are small open cuts, the deposits nowhere having been followed down for more than 50 feet.

Between 1910 and 1912 hundreds of mica claims were taken up by prospectors, syndicates, and companies in the Transvaal, but the lack of a convenient market soon caused most of the miners to quit operations. After a few years practically all the claims were allowed to lapse, and in 1916 the last company ceased operations. In 1917 and 1918, however, operations were resumed by a few of the larger companies, and several tons of sheet mica were produced, four white men and 150 natives being employed. Splitting, grading, and cutting sheds were erected, and it is said that the equipment included 45 improved cutting machines. South African consumption of mica is very small, only some of the larger sheets of best quality being consumed by the electrical and power companies on the Rand and elsewhere. A small mica factory was established at Johannesburg, which manufactured mica lamp chimneys, stove fronts, and built-up mica board to a moderate extent. The mica-mining industry is

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dependent on its export trade and requires great care in grading and packing the mica.

In the Cape Province muscovite has been found in pegmatite veins in granite at Alicedale and Middel Water in Prieska. Only rarely can sheets be obtained exceeding a few inches in size, and almost invariably they are bent or crumpled. The granites have been considerably affected by earth movements subsequent to the formation of the pegmatite veins, and the mica crystals have in consequence been distorted. Mica has also been mined at Jackalswater, north-northeast of Steinbock, in Little Namaqualand, and it was understood a cutting machine was at work in that district. Plates as much as 14 inches across have been found, but they were badly flawed and of little commercial value. At one place greenish mica sheets measuring 5 by 7 inches were abundant. Rich mica dikes are reported on the Bloemsemond farm, in the Gordonia district, but no further information is available.

In Natal mica has been worked in the Umfuli Valley, near Melmoth, and on Mvuzana River, at Fort Yolland, near Eshoe. The last work on the deposit at Fort Yolland was done in 1914. The mica occurs in pegmatite cutting hornblende schist. The pegmatite veins are very irregular and disconnected and range in width from a few inches to 8 feet. The mica is found in "books" from 2 to 6 inches in diameter and 1 to 3 inches in thickness, sparsely scattered through the pegmatite. A very large amount of waste material must be removed in order to extract the mica, which, although of good color, is frequently cracked and bent, owing to the movements to which the pegmatites have been subjected.

The following is a record of prices paid for Transvaal mica, sheeted and packed in wooden cases, in 1917:

Prices of Transvaal mica in 1917.

Size (inches).	In Africa.	In London.
2 by 2	$0.91	$0.97
2 by 3	1.22	1.34
2 by 4	1.62	....
3 by 3	....	1.82
2 by 6	2.43	....
3 by 4	2.68	2.68
4 by 4	....	3.28
3 by 6	3.28	3.41
6 by 6	....	4.38
8 by 8	....	4.87

The total production of the Union of South Africa, as reported, including the two-year period (1902 and 1903) when mica was shipped from Natal, amounts to about 123 short tons, valued at $58,912. The first production in 1902 was that from Natal. Production in the Transvaal began in 1909, and has continued more or less regularly, with an average annual output from 1909 to 1917, of about four tons. The relative importance of the Transvaal mica field would thus seem to be slight. The period of nearly 10 years of experience in developing the mica field should show a much larger production if the field is important. The reason of the cessation of

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production from Natal is not known, but from general considerations it seems unlikely that any part of the Union will develop into a large mica producer.

MADAGASCAR.

Information about commercial mica in the island of Madagascar is very difficult to obtain. Sheet muscovite is reported from many of the pegmatites of the high plateau in the center of the island. Brown muscovite (probably rum colored) is said to be abundant at Ambatondrazaka and Ankazobe. A valuable deposit is reported to occur in the pegmatites of the Olotsingy Mountains, south of Betafo and Ambatofotsikely. It is stated that about 10 tons a month could be produced from these localities. A white muscovite is reported from the Nossi district and from a locality near Varika, in the Province of Mananjary. About 15 per cent of the mica mined in Madagascar is clear, the remainder being very much spotted and stained.

Phlogopite mica is abundant in some of the metamorphosed limestones, especially in those containing humites. Large sheets have been obtained near Ampikaza, Tananarive, Mahafaly, and Fort Dauphin.

Only a very small production of mica is reported from Madagascar. The largest annual output was 6 tons, valued at $442, in 1913, the latest year for which figures are available. The total reported production before 1913, beginning with 1908, amounted to only 1 or 2 tons.

NYASSALAND PROTECTORATE.

Considerable mica was produced in the Nyassaland Protectorate in 1910 to 1912, the total yield being 119 short tons, valued at $55,693, an average of $468 a ton. Such a value would indicate that the mica was of high quality, but no information is available as to the exact location or character of the deposits. It is to be noted that the region lies west and southwest of German East Africa.

RHODESIA.

Dikes of coarse-grained pegmatite containing large books and crystals of muscovite are of fairly common occurrence in the basement complex of southern Rhodesia, but as yet no mica has been mined in that territory. Specimens of clear transparent mica, as much as 5 inches across, were found to be thoroughly satisfactory for electrical insulation. No particulars are known regarding the nature or situation of the deposit. Sheet muscovite has been reported from Limpopo River, in the Tuli district, and from the vicinity of Urungive, in Mashonaland. The occurrence of lilac and blue lepidolite and bronzy zinnwaldite in large crystals, as much as 6 inches across, in lithia greisen southwest of Odzi siding, in the Umtali district, has recently been reported. Lepidolite, the lithium mica, is also found in scaly granular forms without crystalline outline and in compact aggregates in greisenized pegmatite in the Victoria, Belingwe, and Salisbury districts.

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PROTECTORATE OF SOUTHWEST AFRICA.

Mica-bearing pegmatites have a wide distribution in the central and southern portions of southwest Africa. Several dikes of muscovite pegmatite southeast of Klein Kharas, in the Keetmanshoop district were opened some years ago, but most of the mica, which was 8 inches or less in diameter, proved, on being tested electrically, to be too badly flawed to be of commercial value.

KAMERUN.

A good quality of muscovite mica in sheets measuring 16 by 24 inches has been found in pegmatites in Kamerun at Woe Matun, in Dualabezirk, and at Essudasa, in Ossidingebezirk. The difficulties of transportation, however, are so great that they prohibit exploitation. No further information about the character of the deposits is available.

ASIA.

INDIA.

The mica exported from India is all muscovite. A little biotite, obtained in mining the muscovite, is consumed locally, as a medicine, and insignificant quantites of phlogopite have in the past been extracted in Travancore, in southern India, and exported. Negotiations were opened in 1918 looking to a further development of the Travancore properties. The Indian muscovite, like that in all other deposits, ranges in quality from the best to the poorest, but more first-class mica is mined and shipped from India than from any other country. The best mica in Bengal when in plates half an inch thick, has in transmitted light a deep ruby color; hence the term "ruby mica." It has been estimated that only about 5 per cent of all mica received in England from India was suitable for use as electrical condenser mica. Indian mica has been classified as clear ruby, smoky, brown, pale amber, green, slightly stained, black spotted, and silver-white soft. An even more detailed classification has been made by the British Government as a basis for price fixing and is given on page 656. India has been, is to-day, and will continue to be the preeminent mica-producing country of the world. The best Indian mica is unexcelled, and the many years of experience in trimming, sorting, and packing makes shipments of the Indian mica the most desirable.

Commercial mica deposits in India are limited to the peninsula, south of the deformed crystalline rocks of the Himalaya Mountains. The principal mica-producing areas are in Bengal and Madras, but several other parts of India have produced good sheet mica, chiefly Rajputana and Mysore. For the period 1910–1917 Bengal produced about 75 per cent of the sheet mica, Madras about 22 per cent, Rajputana nearly 2 per cent, and all the other localities less than 1 per cent. In these years Bengal has increased its proportionate production, while Madras and Rajputana have relatively decreased.

The mica-producing region in Bengal (which is also described as being in Bihar and Orissa) is in a belt of schists and associated gneissoid granites, 60 miles long and 12 miles broad, from Bendi in the Hazaribagh district, northeastward nearly to Nawadih (Jha-Jha), on the railroad in Monghyr, south of the Ganges River and

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about 200 miles northwest of Calcutta. The mica districts are Hazaribagh, Gaya, and Monghyr, but most of the mines are in the Koderma area, Hazaribagh district. The mica region extends from latitude 24° 25′ to 25° and from longitude 85° to 86° 30′.

The Koderma area (latitude 24° 31′ and longitude 85° 38′) has irregular surface features, the schist forming a scarp, which is cut by many passes and is rapidly being eroded by the action of rivers. Although most of the mica-bearing pegmatites in this area have been prospected or mined, much of the work done was superficial, and with a very few exceptions the mines are very shallow, and their excavations which strictly follow the leads of good mica crystals, are long, meandering holes reaching down to several hundred feet. Open cuts are frequently made down to about 30 feet, after which the sides begin to cave in. In many places pegmatites are decomposed to a depth of 100 feet owing to the kaolinization of the feldspar. A few mines have recently adopted[1] better mining methods with good results, and it seems probable that the extension of modern methods will be of great benefit to the Indian mica-mining industry.

The schist formation consists of mica schists, composed of quartz and mica together with one or more of the minerals kyanite, sillimanite, magnetite, chiastolite, hornblende, garnet, and scapolite, as well as quartzites and limestones. There are also schists and gneisses with diopside, anthophyllite, talc, and chlorite. The so-called dome gneiss consists of low rounded hills of a gneissic granite. Both the dome gneiss and the schists contain pegmatites, but only those in the schists carry commercial mica. The pegmatites are generally parallel to the strike of the schist but also cut across it. They range in thickness from a few inches to 150 feet, but the workable dikes average about 10 to 40 feet and are present in great abundance. The mica crystals are collected in bunches or rows along one or both sides of the dike but chiefly in shoots near the center of the dikes. At some places the mica books are best on the hanging wall, at others they are best on the footwall, and at still others they are uniformly distributed through the rock. It has been said that if masses of fairly pure feldspar contain large crystals of mica, then extensive bodies of massive quartz are present in the dike within at least 20 feet. Up to about 1900 there were from 200 to 300 so-called mines in the Koderma area, but only one vertical shaft without crosscuts or adits was being sunk. Mining conditions there have improved in the last decade or two. Very much of the mica is ruined in mining. Preliminary shafts are often sunk in the mica-bearing pegmatite instead of in the adjacent country rock, as they should be, for the mica could then be extracted from the pegmatite by overhead stoping.

One mine in a pegmatite dike 40 feet thick, worked by modern methods in 1900 for more than 300 feet, yielded 40 pounds of mine-run mica or 10 pounds of trimmed mica for each ton of pegmatite rock removed.

The other important mica area in India is in Madras, especially in the Nellore district, which extends from about longitude 79° 45′ to 80° and from latitude 14° to 15°, covering about 35 miles from east

[1] Dickson, A. A. C., The mica miner's and prospector's guide, 50 pp., 12 illus., London, E. & F. N. Spon (Spon & Chamberlain, 120 Liberty Street, New York), 1919.

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to west and about 100 miles from north to south. The country rock is a mica schist with included pegmatites, forming a low-lying plain on which the rivers continually deposit alluvium. Much of the rock and many of the mica-bearing pegmatites are therefore covered and concealed and probably never will be detected. The area most intensely worked is about 20 miles wide (from east to west) and at least 60 miles long and contains many mica-rich pegmatites which are generally exploited by open cuts, mining in these flat areas being much more expensive than in the hilly ground of Bengal. The pegmatites apparently are more lenslike than those in Bengal, one of the best mines in the region being in a pegmatite body 150 feet wide and 300 feet long. Much of the mica from Nellore is of a greenish color, although brown, amber, and ruby mica is also found. A soft bleached mica with silvery luster also occurs here. A second but relatively not very important locality in Madras is at Nilgiris, in southeastern Wainad (about longitude 76° 45′ and latitude 11° 25′), where pegmatite dikes as much as 8 feet thick intrude a biotite gneiss, the mica in the pegmatites lying between the quartz and the feldspar. Much of the mica from Madras is trimmed into neatly cut rectangles of the largest possible size although some of it is sickle-trimmed, like that of Bengal. The rectangular trimmed Madras mica, however, is not "cut mica," the rectangular pieces being neither strictly rectangular nor of uniform size nor cut to any standard size.

Good sheet mica is reported to be abundant in Ajmere and in Merwara, in Rajputana, but very little is known in regard to the character of the deposits.

The mining of mica in India is very old, the mines in Bengal having been worked for hundreds of years. Those near Nellore, in Madras, are comparatively recent, having been first worked in 1887. Nearly a hundred years ago about 5,000 natives were employed in the Bengal mica mines, and it has been estimated that in the last few decades about 15,000 men, women, and children have been annually employed in mica mining.

The output in 1849, all of which was consumed locally, has been estimated at nearly 4,000 tons. The first exports of mica (410 tons) were made in 1863, the mica previously mined being used locally, chiefly for ornamentation, for medicinal purposes, and as protection against the intense heat. Probably most of the mica first exported was used in the stove industry and for general glazing. The use of mica for electric insulation and the very rapid extension of the electrical industry soon created a steady demand for mica and placed mica mining on a firm basis.

Early figures of production are probably not available. In 1890 the output was placed at 346 short tons; for the next four years the output overaged annually 206 tons; for the following five-year period, from 1895 to 1899, the average annual output was 520 short tons. In 1898 the waste heaps were turned over and considerable mica suitable for splittings was collected and split into thin films or splittings. This augmented considerably the production for the ensuing years. In 1900 the production was 1,026 short tons. Since then it has been more than 1,000 tons a year. For the 10-year period 1901–1910, the average annual production was 1,671 short tons, with a maximum of 2,677 short tons in 1908 and a minimum of 1,108 short

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tons in 1904; for the seven-year period 1911–1917 the average annual production was 2,040 short tons, and for 1918 a production of about 3,000 short tons was expected. The yearly average production for the period 1901–1917, inclusive, was 1,823 short tons.

For the period 1906 to 1917, inclusive, India furnished 66 per cent of the world's sheet mica, which amounted to 73 per cent of the world's sheet muscovite, the United States, India's only serious present competitor in muscovite, producing 23 per cent.

The future of mica mining in India looks as promising as its past. Mining has not been so intensive that every deposit has been worked or that the deposits worked have been exhausted. In fact, with improved mining methods, nearly all the mines once worked, can probably be made to yield good mica again. The best of the deposits have been more or less worked, but extensive underground mining at a minimum cost would no doubt yield good returns. Additional localities in India which yield good sheet mica are being found and opened, and with a good market and fair price, the mica-mining industry should continue to flourish.

The condition of the mica trade in India was fairly good during the first half of 1914, prices being slightly lower than in 1913, which was an exceptionally good year. The trade suffered severely after the beginning of the European war, and the output decreased. A large part of the demand for this mineral had hitherto come from Germany for use in its electrical industries. Certain firms with German interests, which were large purchasers of mica, have, it is stated, closed down. The export of mica to other countries in Europe was practically cut off, and the industry generally was much hampered by the abnormally high rates for ocean freights and insurance brought about by the war. There was considerable difficulty with regard to shipments to America, to which large consignments are sent direct in normal times. A great demand for mica for use in the manufacture of munitions soon arose, however, and India was called upon for a largely increased output and made every effort to meet the requirements of the British Ministry of Munitions. Exports of mica from British India, elsewhere than to the United Kingdom, were prohibited in September, 1915. This measure was not, however, sufficient in itself to stimulate production and shipments or to insure the careful selection and grading of Government standard mica. In May, 1916, a Government agency was organized for the purchase at fixed rates of all mica suitable for munitions. Finally in March, 1917, it was found desirable to improve the system still further. Prices had meanwhile risen in the London market, and free export to that market was again permitted without the intervention of the Government agent, whose activities were then confined to the requisitioning of stocks unreasonably withheld up country. Protracted rains accounted for a temporary serious falling off in the output, but shipments steadily increased, and the production for both 1916 and 1917 exceeded that of any year since 1908. The expected production for 1918 was estimated at more than 3,000 short tons.

Attention has also been paid by the geologists of India to the geologic side of the industry, and members of the India Geological Survey have been engaged in giving technical advice and assistance in established mining areas and also in searching for new sources of

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supply, especially in the Bengal region. A large number of promising veins of pegmatite containing ruby mica of unusually high average quality were found in the pegmatites of the schist area in the neighborhood of Nansa, a few miles north of Gangapur, Udaipur, and negotiations were begun for the opening of the deposits.

Mica mining is so old and well-established an industry in India that the uncertainties and difficulties incidental to such mining have been largely overcome. Labor is plentiful, transportation offers no serious difficulties, and the processes of grading, preparing, and packing the mica for shipment are better understood in India than in any other country.

A certain small percentage of the mica mined is consumed locally. Considerable mica of poor grade is used for ornamentation and decoration, and a small quantity of the larger sheets of good quality serve as the material on which pictures are painted. Although no actual figures of such consumption are available, it has been estimated that India annually consumes several hundred tons of mica, presumably chiefly sheet mica. The refuse from trimming the sheets and scrap mica otherwise obtained is also used as insulation for boiler and pipe coverings and for covering roofs as a protection from heat, a half-inch layer being said to be very efficacious.

Of the mica exported from India in 1903 to 1914 about 55 per cent went direct to the United Kingdom, 17 per cent to the United States, 16 per cent to Germany, and 8 per cent to Holland. Of the 55 per cent sent to England, a good deal was no doubt reexported to the United States and to Germany, and likewise a good deal of the mica exported to Holland doubtless eventually went to Germany. Although no figures are available, it seems probable that from 40 to 50 per cent, or nearly half, of the mica exported from India eventually went to Germany for ultimate consumption.

The relations of the figures of production and of export for India are difficult to interpret fully. The export figures represent the actual quantity of mica leaving India for any specific year and therefore represent closely the mica that actually goes into consumption, but they do not include the mica consumed in India and may represent in part mica that was mined and sold (and therefore "produced") several years before it was exported. On the other hand, the figures of production are certainly low, as much mica obtained is not reported to the Government and does not enter into the official figures of production. A table showing production and exports as reported by the Indian Government and by the British Government shows so many discrepancies that it is hopeless to obtain figures that are incontrovertible.

CEYLON.

The mica mined and exported from Ceylon is essentially phlogopite, which occurs in irregular veins, rarely more than 2 feet wide, traversing a granitic rock (granulite), especially near its contact with crystalline limestone. Detailed accounts of the occurrence and extent of these mica deposits could not be found, but Ceylon has been producing small quantities since 1897 and possibly earlier. The

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production has never been large, reaching a reported maximum of 23 shorts tons in 1907. For the period 1897 to 1908 the annual average (including three years of no production) was about 5 tons. No production was reported for the period 1909 to 1912, and almost no information is available for later years. A very little phlogopite was mined in 1918.

CHOSEN (KOREA).

The mica mines of Chosen (Korea) have been described by Shigetaro Kawasaki.[1] Both muscovite and phlogopite occur and have been known and used by the natives of Chosen for a long time. In 1909 mining for mica in Chosen was undertaken by the Japanese. No figures of production or value are given in the English text of Kawasaki's paper.

CHINA.

Mica that seems to be of good quality is reported by Consul E. C. Baker, of Chungking, China, to be found near Sungpan, in the northern part of Szechwan Province, central China, and one of the large Chinese firms there, which has a branch office in Shanghai, is prepared to export this product. About 1914 the price for delivery at Shanghai was between 9 and 10 cents United States currency a pound. About 15,000 pounds can be delivered every year, but according to reports the mica has no value as sheet. Mica of good quality, somewhat cloudy but of large size, is also reported from Tschoutschong, Province of Shantung. The supply is said to be large, but the deposit is far from transportation. Large deposits are said to be exposed in an area of 50 square miles about 50 miles from Kiaochow Bay. The mica-bearing pegmatite dikes are 10 feet thick.

The samples of mica received in this country from China are worthless as sheet, and China still has to demonstrate that it can produce sheet mica of value.

JAPAN.

Persistent reports have been made of a production of mica in Japan, although no authentic information could be obtained. Several Japanese geologists have stated that no sheet mica is produced in Japan and that the imports from Japan, as stated in some reports, may have originated in some other country.

The growth of the electrical industry in Japan has been very great in the last 10 or 15 years. Japan has nearly 700 central-station systems, 530 electric power and light systems, 42 electric tramways, and 48 combined railway and lighting systems, together with 1,609 private and 53 Government plants. The country has changed from an exclusive importer of electrical goods to an exporter.

[1] Mica in Chosen: Chosen Mineral Survey Bull., vol. 1, pt. 2, Seoul, 1916.

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SIBERIA.

There is no authentic record of any exploitation of mica anywhere in Russia. The term muscovite or muscovy glass, derived from the old name of the Russian Empire, would suggest Russia as the source of muscovite, but the mica referred to doubtless originally came from India. Sheets of muscovite are found in many of the pegmatites of the Ural Mountains but not in commercial sizes or quantities. In recent years sheet mica has been reported as occurring at several places in Siberia. The Tasseifsk mica deposit, in Yeniseisk Province, lies on the right side of River Tasseif, near the small village called Kondakoff, about 12 miles from the point where the Tasseif falls into Angara River. Transparent sheets 2 feet across have been found here. The Kansky mica deposit, in the Krassnoyarsk district, is near the Yakovlieff ironstone mine on Kan River, near the mouth of Varga River. Mica has also been discovered at several places on the Baikal Circle Railway.

AUSTRALASIA.

AUSTRALIA.

Commercial sheet mica occurs[1] abundantly in Australia, very coarse pegmatites, usually micaceous, being of common occurrence throughout the very large areas of pre-Cambrian rocks. Sheet mica has been mined in Northern Territory, Western Australia, and South Australia and is known to be present in Queensland and New South Wales. The chief commercial mica in Western Australia is lepidolite, although sheet muscovite is also present. Muscovite is the only mica mined at the other places.

Apparently the most valuable deposit of sheet mica is in the central part of the island, at the south end of Northern Territory, in the Macdonnell Ranges. The nearest inhabited place is Alice Springs, a small mining community. This place is fully 400 miles from Oodnadatta, at the north end of the Northern Railroad line of South Australia. Oodnadatta is nearly 700 miles from Adelaide and 400 miles from Port Augusta. The nearest railway is a single narrow-gage track and until the railway line is extended entirely across the continent from south to north the deposits in the Macdonnell Ranges are too far from transportation to be worked economically. The muscovite found here occurs in abundance in large sheets, clear, light colored, and nearly free from flaws. Sheets several feet across have been obtained.

The exact locality of the mica deposit is given as the northern slopes of Harts Range in the northeastern portion of the Macdonnell Ranges, about 25 miles in an air line north-northwest of Claraville and about 5 miles southeast of the intersection of longitude 135° and latitude 23°. The deposits exploited in the past lie east and west of Mount Palmer. The country rocks are gneisses and schists, prob-

[1] The writer is indebted to Prof. W. G. Woolnough for an extended statement on the occurrence of commercial mica in Australia.

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ably of Archean age, with many pegmatite dikes. These dikes are irregular in shape and size, branching out and abruptly widening and thinning. Massive quartz in large pieces is abundant, but the mica is reported to occur in an irregular and uncertain way. It is probable, however, that the small open cuts made did not suffice to indicate clearly the mode of occurrence of the commercial sheets. A number of claims were worked here in the nineties, and the following brief sketch of these claims is taken in substance from Brown's report[1] on the region.

The Oolgarinna or Chambers mine is an open cut or quarry, 15 feet deep. The country rock is a micaceous schist, and the pegmatite contains large and solid masses of feldspar and of quartz, with smaller crystals of mica. Large sheets of mica were found at the junction of the quartz and feldspar, at the edges of the dike, and around inclusions of country rock (horses) in the dike. The large mica crystals were generally on the hanging wall. Sheets 1 foot across were plentiful, and considerable mica was still seen when operations ceased. One immense crystal of mica measured 6 by 5 by 4 feet and yielded nearly 800 pounds of cut mica.

Pope's claim is a small excavation on a pegmatite carrying large masses of quartz. Valuable mica crystals lie between the feldspar and the quartz. Nearly half a ton of cut mica was obtained from this claim.

The Disputed claim was opened for 50 feet along the hanging wall of a pegmatite, striking No. 80° W. and dipping southwest. The width of the pegmatite dike is said to be about 300 feet.

Mullen's claim is on a coarse pegmatite 20 feet wide, striking N. 10° W. About 2 tons of rough trimmed mica was obtained.

Gall's claim is on a pegmatite 60 feet wide, and yielded a ton of rough trimmed mica. Other claims were known as Williams's, Stone's, Thompson's, and Floyd's. On Stone's claim, a few miles west of Oolgarinna claim, a 25-foot shaft was sunk.

The pegmatite dikes carrying mica are known to extend eastward along Harts Range for a considerable distance. The small open cuts and quarries developed did not suffice to give any indication of the abundance of sheet mica in the pegmatites, which are numerous and extend over a large area. The systematic development of this field can probably be successfully carried out by experienced miners if supported by sufficient capital and if the transportation facilities are such that the product can be brought to the market.

Prof. Woolnough regards the Harts Range deposit as one of the important mica deposits of the world, having great future possibilities.

A total production of nearly 100 tons was made in the years 1890 to 1900, and the mica as sold was valued at about $500 a ton, a very high price, especially for that time. No mining in this region has been reported since 1900.

Around Bynol Harbor, southwest of Port Darwin, in Northern Territory, an apparent extension of the Coolgardie and Pilbara

[1] Brown, H. Y. L., Reports on Arltunga gold field and Harts Range mica field, pp. 4–5, map, Adelaide, South Australia, 1897.

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regions (described in the next paragraph) contains lithium-bearing pegmatites with sheets of muscovite.

In Western Australia mica-bearing pegmatites are very abundant. In the Darling Ranges, a few miles east of Perth, sheets of muscovite of fine quality 6 or 8 inches in diameter were obtained near Toodyay (formerly called Newcastle). Sheets of muscovite 3 inches in diameter have been collected near Donnybrook, about 100 miles south of Perth. At Ravensthorpe, about 130 miles east of Albany, the numerous pegmatites contain abundant lithium minerals, and large sheets of lepidolite as well as muscovite are present. Farther north, in the Coolgardie-Londonderry area, clear sheets of lepidolite 1 foot across are bundant. The maximum size is about 15 by 12 inches, and the average size 5 to 6 inches. The mica is clear and splits easily, but the low fusibility of the lepidolite detracts considerably from its value. In the Pilbara gold field, in the extreme northwestern part of Western Australia, sheets of both lepidolite and muscovite have been mined.

In South Australia the highly metamorphosed schists and gneisses of the Barossa Ranges contain many mica-bearing pegmatites. The most noteworthy locality is near Williamstown, east of Gaoler, and about 40 miles north of Adelaide. Here a pegmatite dike 10 feet wide and dipping 60° NE. has been exploited for several hundred feet. Two shafts have been sunk to depths of 65 and 36 feet. The coarsest mica is on the hanging wall and in areas a few feet across. The mica is considerably fractured and wavy and shows numerous stains and spots with occasional clear patches. The largest sheets measured 10 by 8 inches, and the average was 5 by 3 inches. In 1890 some exploiting was done on a pegmatite 30 feet wide, and books of mica 6 to 15 inches square were obtained. No figures of production before 1908 are available, and it was only in 1917 that 38 tons of mica was produced here. The average price obtained, about $44 a ton, indicates that the mica is probably not of high quality, and as the miner has to ship his product to England and await sale there, the development of this field does not look promising.

Queensland has a mica belt several miles long on Rifle Creek, a tributary of Upper (West) Leichhardt River, about 68 miles due west of Cloncurry, but the distance of nearly 500 miles to the nearest railroad militates against the development of the field. The country rock consists of hornblende and mica schists, with numerous mica-bearing pegmatites 10 to 12 feet thick. Some dikes contain very much mica, others have considerable quartz. The mica sheets reach a size of 9 inches square. Sheet mica also occurs in the pegmatites of the mining fields of northern Queensland. Pegmatite dikes containing large crystals of mica have been noted on Einasleigh River, southeast of Georgetown, and at Brookland, near Junction Creek, both within the Etheridge gold field.

In New South Wales mica-bearing pegmatites are prominent in the area northeast of Broken Hill, where sheets of muscovite several inches in diameter are obtained.

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Mica produced in Australia, 1891–1917.

Year.	Northern territory.		Western Australia.		Southern Australia.		Total.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
1891	a 12	$5,884					12	$5,884
1892	a 2	964	(b)	$122			2	1,086
1893			(b)	19			(b)	19
1894	a 24	12,312					24	12,312
1895			(b)	14			(b)	14
1896	3	1,616					a 3	1,616
1897	48	24,036	2	1,017			a 50	25,053
1898	1	487					a 1	487
1899			1	243			1	243
1900	1	a 487		19			1	506
1901–1907								
1908			(b)	49			(b)	49
1909–1913								
1914			a 3	1,572			3	1,572
1915			(b)	127			(b)	127
1916			(b)	49			(b)	49
1917					38	$1,640	38	1,640

a Estimated. b Not more than a few hundred pounds.

NEW ZEALAND.

Near Charleston, south of Westport, New Zealand, a large pegmatite was worked for mica in 1911 and 1912. The mica is dark colored and cross-grained, and the largest sheets obtained measured only 6 by 4 inches. Practically all the mica mined was suitable only for grinding, very little usable sheet being obtained. Large sheets of muscovite are reported to occur near Dusby Sound, in southwestern Otago.

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COAL—PART A, PRODUCTION.

By C. E. LESHER.

INTRODUCTION.

GENERAL STATEMENT.

The report on coal for 1918, like the reports for 1915 and 1917, treats of production in Part A and distribution and consumption in Part B. Throughout 1918 the statistical force of the Geological Survey engaged in the collection of statistics on coal was merged with the much larger force of the Fuel Administration in the common purpose of gathering all the facts needed by the Fuel Administration and its staff in the administration of the problems of the production and distribution of fuel during the war.

A vast fund of statistical information on coal was collected through the efforts of the Fuel Administration, and the more important parts of it have been assembled for publication by the Fuel Administration in the report of the distribution division, which appears in three parts—Part I, a description of the work of the distribution division; Part II, a description of the zone system; and Part III, statistical tables. The information contained in Part A of this report is almost entirely that regularly compiled by the Geological Survey, but the data in Part B are drawn from the statistics collected by the Fuel Administration, summarized by States and coal fields and for calendar years. Because of lack of funds there is no present prospect that statistics of distribution can be compiled by the Geological Survey for 1919.

ACKNOWLEDGMENTS.

So general and hearty was the response of coal producers and shippers, railroad officials, and consumers to the many requests made of them for information that individual mention is not possible. Appreciation is expressed of the loyal support rendered by the secretaries of the local coal operators' associations, who through their intelligent and persevering efforts in the collection and interpretation of information lightened the work of the writer and his assistants. The State geologists of Alabama, Illinois, Iowa, Georgia, Maryland, North Carolina, Oregon, Pennsylvania, Virginia, and Washington cooperated in the collection of reports from the coal operators. Special credit is due to Miss Lida Mann and Miss J. M. Corse, of the United States Geological Survey, under whose direction the statistics of production of bituminous coal were compiled, and to other members of the staff in both the Geological Survey and the Fuel Administration. The statistics of anthracite were compiled by Mrs. H. L. Bennit; much of the responsibility for the statistics for 1918 contained in Part B was assumed by the writer's assistant, Mr. W. P. Ellis, of the Fuel Administration.

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UNIT OF MEASUREMENT.

The standard unit of measurement adopted for this report is the net ton of 2,000 pounds, although for certain uses the gross ton of 2,240 pounds is employed. Pennsylvania anthracite is mined and sold by the gross ton, and that unit is used in the part of the report dealing with anthracite. All other statistics of production reported to the Geological Survey in gross tons have been reduced to net tons, and unless otherwise expressly stated the net ton is meant where any statement of quantity is made in the text.

There is a steadily growing sentiment in favor of the universal use of the net ton of 2,000 pounds as the standard of the coal trade, particularly for bituminous coal in the Eastern States, where now both gross and net tons are used. The use of two units is of course undesirable; but State and municipal laws in many places require the gross ton, and freight rates throughout a section of the Eastern States are now fixed on this basis, and these facts make it difficult to effect any immediate change in standard. Foreign trade and shipping rates are expressed in either gross or metric tons, and here, too, the use of two units is undesirable. The general use of the net ton in the United States, even in the anthracite region, is advocated.

REVIEW OF THE COAL INDUSTRY IN 1918.

The dominating factor in the coal industry in 1918 was the control over every feature, from production to consumption, exercised by the Fuel Administration. The chaotic conditions that marked the closing months of 1917 continued through the first two months of 1918, for the situation was so bad that no hope was entertained of getting the distribution of coal into orderly shape until the effects of the extreme weather had passed and the organization of the Fuel Administration had progressed to the point of enabling it to assume full control. Much of the criticism that has been leveled at the Fuel Administration is based on the happenings of the winter of 1917–18, when no hand could stay the fury of the elements and when sufficient time had not elapsed from the inception of Government control to furnish an adequate organization to handle the situation.

Contrasted with the uncertainty and disturbance in 1917 and the first months of 1918 was the definiteness of purpose and of control that existed once the Fuel Administration had become organized and its policies had become formulated and were appreciated by the industry and the public. The definite and positive control of distribution by the Fuel Administration began on April 1, 1918, with the installation of the zone system and the allotment of coal under the budget system. By the 1st of July it was apparent to those closely in touch with conditions that, barring unforeseen contingencies, the country would be fueled for the year, and by the 1st of October there was no doubt as to the outcome. In fact by October the problem in certain areas was not to find coal to meet the demand, but to find consumers to take the coal that was being produced. After the signing of the armistice, November 11, the demand for coal appreciably slackened, because of the cessation of war industry, and by the end of the year the lack of market was an important

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factor with many bituminous coal districts and mines operating on part time.

There was no coal shortage in 1918; sufficient coal, both anthracite and bituminous, was produced to care fully for all needs, and there can be no doubt that, even had the war continued, the country would not have suffered from lack of fuel. The mildness of the winter of 1918–19 of course entailed a decrease in the requirements, particularly of anthracite for house use.

In six months of the year, from May to October, the production of bituminous coal exceeded 50,000,000 tons a month, and in July and August it exceeded 55,000,000 tons. These figures indicate the present possibility of a production of 600,000,000 tons a year. If the year is viewed as a whole, it is evident that the only factor limiting the production of bituminous coal was lack of demand—that is, in 1918 all the coal required by consumers was produced, and a greater quantity could and would have been produced had the demand continued in October, November, and December as strong as it was in the first eight months of the year. The production of bituminous coal increased faster than the consumption, and this, it may be stated, is the only sure way to prevent a coal shortage. When the margin between supply and demand is small consumers are inclined to overstate their requirements through fear of actual shortage, and a condition of panic is thus induced. It is safe to say that even had the war continued through the winter of 1918–19, the supply of coal in the hands of consumers and the facilities for production and distribution were such that the market for coal would have declined and prices here and there would have dropped below the Government maxima.

That a greater output was not reached month by month in the first eight months of the year when the demand was at its height, was due to car shortage. In the first five months of the year lack of cars was a large cause of nonproduction, but from June on the supply of cars was increased and, except for a brief period in August, car shortage was relatively of little more importance than the other causes affecting output. The accompanying diagram (fig. 69) shows the percentage of full-time operation and of losses by causes. This diagram should be considered in conjunction with figure 72 (p. 703), which shows production by weeks in 1918.

Consumption of bituminous coal in 1918 was notably increased by the establishment or enlargement of several large war-munition plants, such as the smokeless-powder plant at Nashville, Tenn., the powder plant at Hopewell, Va., and the Muscle Shoals nitrate plant in Alabama. The use of electric power by the shipyards and other establishments working on war contracts put excessive loads on many central power stations along the Atlantic seaboard and required the consumption of additional quantities of steam coal. Offsetting these increased industrial requirements were the efforts to conserve coal by improved practice in utilization, efforts that in some States, as Massachusetts, resulted in appreciable saving.

Unusually large stocks of bituminous coal were accumulated throughout the country in the summer and fall of 1918. The Fuel Administration adopted the definite policy of urging early and abundant storage of coal and controlled the distribution of stocks only in order to assure to all, in their order of importance, a fairly equal share of such future supplies. The consumers farthest from the mines, as

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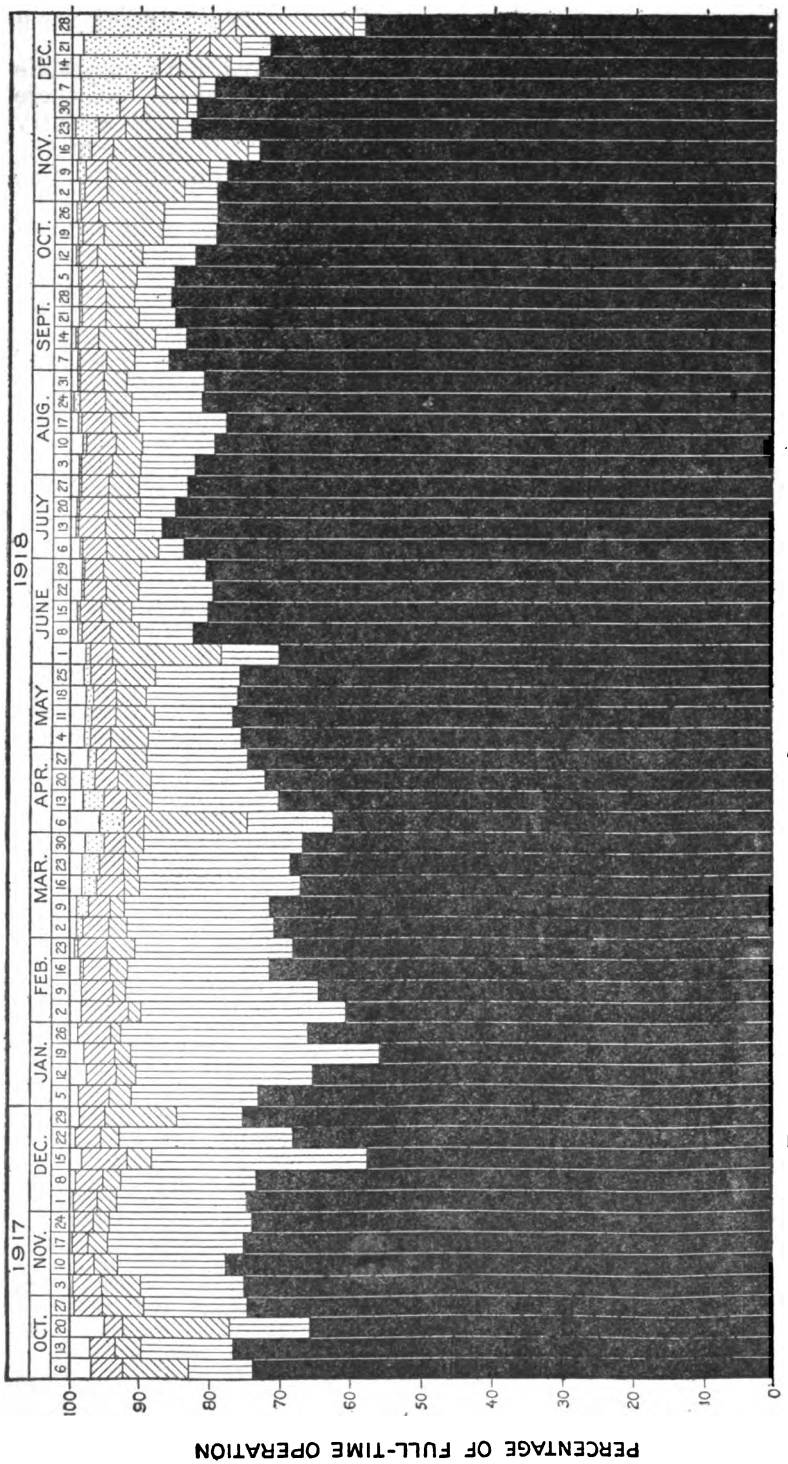
1917
1918
OCT. NOV. DEC. JAN. FEB. MAR. APR. MAY JUNE JULY AUG. SEPT. OCT. NOV. DEC.
PERCENTAGE OF FULL-TIME OPERATION
100 90 80 70 60 50 40 30 20 10 0
Produced
Lost, account of car shortage
Lost, account of labor shortage and strikes
Lost, account of mine disability
Lost, account of no market
Lost, no cause reported

FIGURE 60.—Percentage of full-time operation of all bituminous coal mines in the United States and of losses, by causes and weeks, from October, 1917, to December, 1918.

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in New England, the Northwest, Michigan, and on the southeastern Atlantic seaboard, were provided earlier and with larger supplies than the consumers nearer the mines. Thus in parts of New England stocks sufficient for 15 weeks were accumulated by early fall, compared with stocks for 3 to 6 weeks in Ohio.

Prices of coal were regulated throughout the year by the Fuel Administration. The subject of prices has been discussed in a separate report,[1] to which the reader is referred.

The supply of labor for the mining of bituminous coal was ample in 1918, but scarcity of men restricted the output of Pennsylvania anthracite. Although the total number of men employed in the production of bituminous coal was greater in 1918 than in 1916 or in 1917, the increase was in the number of surface employees and not in those at work underground. On pages 711-724 of this report the statistics of labor are reviewed in detail. Strikes were almost unknown in 1918, the record in this respect being the best covered by the available statistics.

For a more intimate and detailed survey of the history of the coal industry in 1918 the reader is referred to the report of the distribution division of the Fuel Administration already mentioned. The report of the engineers' committee of the Fuel Administration contains diagrams of costs of production of both bituminous coal and anthracite as compiled for use in fixing prices. The section on the Fuel Administration in the report by the War Industries Board on government control of prices gives additional data on the industry in 1918.

PRODUCTION.

Summary of statistics of coal produced in the United States in 1917 and 1918.

	1917		1918	
	Quantity (net tons).	Value.	Quantity (net tons).	Value.
Bituminous coal and lignite	551,790,563	$1,249,272,837	579,385,820	$1,491,809,940
Pennsylvania anthracite	99,611,811	283,650,723	98,826,084	336,480,347
	651,402,374	1,532,923,560	678,211,904	1,828,290,287

	Increase, 1918.			
	Quantity.		Value.	
	Net tons.	Per cent.	Dollars.	Per cent.
Bituminous coal and lignite	+27,595,257	+5.0	+$242,537,103	+19.4
Pennsylvania anthracite	− 785,727	−0.8	+ 52,829,624	+18.6
	+26,809,530	+4.1	+ 295,366,727	+19.3

The production in 1918 of 579,385,820 net tons of bituminous coal and of 98,826,084 net tons of Pennsylvania anthracite established a new high record for bituminous coal and was second only to 1917 in

[1] Lesher, C. E., Prices of coal and coke, 1913–1918: U. S. Geol. Survey Mineral Resources, 1918, pt. 2, pp. 15–115, 1919.

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the output of anthracite. The increase in the production of bituminous coal exceeded that of 1917 by 27,595,257 tons, or 5 per cent. The decrease in output of anthracite was 785,727 net tons, or 0.8 per cent. For bituminous coal 1918 marks the fourth successive year of increase following the depression of 1914, the production in 1918 being 37 per cent greater than in 1914.

New high records of production of bituminous coal were set in 1918 in 15 out of 30 States. In the remaining 15 States the highest re-

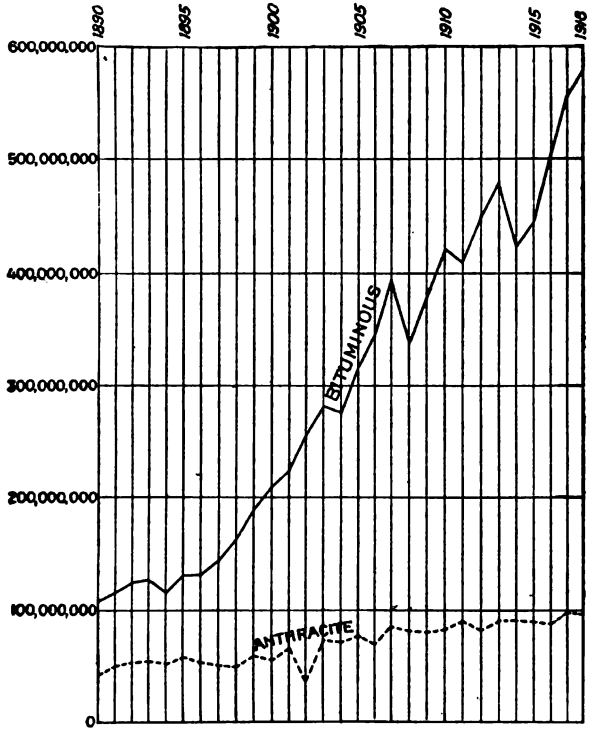

FIGURE 70.—Production of bituminous coal and anthracite in the United States, 1890-1918.

corded production was as follows: In 5 States, Alabama, Colorado, Iowa, Missouri, and North Dakota in 1917, Arkansas in 1907, California in 1880, Georgia in 1903, Maryland and Michigan in 1907, North Carolina in 1899, Oregon in 1904, South Dakota in 1914, Tennessee in 1910, and Texas in 1913. The six leading States in the production of bituminous coal, Pennsylvania, West Virginia, Illinois, Ohio, Kentucky, and Indiana were among those setting new high records in 1918.

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Coal produced in the United States in 1918, by States, and highest recorded production, by years.

State.	Quantity.	Maximum production.	
		Year.	Quantity.
	Net tons.		*Net tons.*
Alabama	19,184,962	1917	20,068,074
Alaska	75,606	1918	75,606
Arkansas	2,227,369	1907	2,670,438
California and Idaho	6,400	1880	[a] 236,950
Colorado	12,407,571	1917	12,483,336
Georgia	66,716	1903	416,951
Illinois	89,291,105	1918	89,291,105
Indiana	30,678,634	1918	30,678,634
Iowa	8,192,195	1917	8,965,830
Kansas	7,561,947	1918	7,561,947
Kentucky	31,612,617	1918	31,612,617
Maryland	4,497,297	1907	5,532,628
Michigan	1,464,818	1907	2,035,858
Missouri	5,667,730	1917	5,670,549
Montana	4,532,505	1918	4,532,505
New Mexico	4,023,239	1918	4,023,239
North Carolina	1,420	1899	26,896
North Dakota	719,733	1917	790,548
Ohio	45,812,943	1918	45,812,943
Oklahoma	4,813,447	1918	4,813,447
Oregon	13,328	1904	111,540
Pennsylvania (bituminous)	178,550,741	1918	178,550,741
South Dakota	7,942	1914	11,850
Tennessee	6,831,048	1910	7,121,380
Texas	2,261,135	1913	2,429,144
Utah	5,136,825	1918	5,136,825
Virginia	10,289,808	1918	10,289,808
Washington	4,082,212	1918	4,082,212
West Virginia	89,935,839	1918	89,935,839
Wyoming	9,438,688	1918	9,438,688
Pennsylvania (anthracite)	98,826,084	1917	99,611,811

[a] California only.

The progress of the industry from 1890 to 1918 is shown graphically in figure 70. It will be noted that the development of the anthracite industry has in no way kept pace with that of bituminous coal. In 29 years the production of anthracite slightly more than doubled, but that of bituminous coal increased fivefold. The reason for this discrepancy is found primarily in the limited reserves of anthracite as compared with the almost boundless resources of bituminous coal, but it also lies in the fact that anthracite is essentially a domestic fuel whose production has followed more closely the increase in population, whereas bituminous coal is the fuel of industry and has kept pace with industrial expansion in the country. Furthermore, the yearly variations in the production of anthracite are largely the result of weather conditions; but the yearly variations in the production of bituminous coal follow the curve of industrial expansion and depression.

The production of bituminous coal and lignite in the United States, by months in the six years 1913 to 1918 is given in the following table and is shown graphically in figure 71. The significant feature of this diagram is the seasonal drop in the curve in the years 1913 to 1916, and the practical reversal of this drop by a rise in the middle of 1918.

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Bituminous and anthracite coal produced in the United States, 1913–1918, by months, in net tons.[a]

	1913	1914	1915	1916	1917	1918
Bituminous:						
January	42,276,000	40,188,000	37,190,000	46,596,000	47,967,000	42,227,000
February	37,057,000	35,472,000	29,321,000	45,187,000	41,353,000	43,777,000
March	37,536,000	45,455,000	31,801,000	43,827,000	47,869,000	48,113,000
April	34,169,000	23,609,000	29,968,000	33,628,000	41,854,000	46,041,000
May	37,205,000	28,551,000	30,938,000	38,804,000	47,086,000	50,443,000
June	37,405,000	31,412,000	33,957,000	37,742,000	46,824,000	51,138,000
July	38,858,000	34,305,000	35,573,000	38,113,000	46,292,000	54,971,000
August	41,590,000	37,751,000	38,161,000	42,696,000	47,372,000	55,114,000
September	41,424,000	39,019,000	40,964,000	42,098,000	45,108,000	51,183,000
October	46,164,000	37,685,000	44,198,000	44,807,000	48,337,000	52,300,000
November	43,233,000	33,392,000	44,737,000	44,927,000	47,690,000	43,895,000
December	41,519,000	35,862,000	45,814,000	44,098,000	44,037,000	40,184,000
Anthracite:						
January	8,396,000	6,878,000	6,337,000	7,649,000	7,672,000	7,270,000
February	7,519,000	5,477,000	5,703,000	7,404,000	6,688,000	7,494,000
March	6,505,000	6,863,000	6,654,000	7,964,000	9,026,000	9,382,000
April	7,906,000	8,069,000	8,725,000	6,887,000	7,222,000	8,211,000
May	7,945,000	8,348,000	7,807,000	7,212,000	8,933,000	8,880,000
June	7,911,000	8,147,000	7,157,000	7,327,000	9,103,000	8,855,000
July	7,272,000	7,165,000	6,691,000	7,062,000	8,684,000	9,134,000
August	7,116,000	7,288,000	7,161,000	7,190,000	9,258,000	9,258,000
September	7,384,000	8,301,000	7,423,000	7,206,000	8,230,000	8,038,000
October	8,399,000	8,830,000	8,761,000	7,630,000	9,183,000	8,105,000
November	7,668,000	7,878,000	8,514,000	7,790,000	8,453,000	6,803,000
December	7,504,000	7,578,000	8,062,000	7,257,000	7,360,000	7,396,000
Grand total, bituminous and anthracite	569,960,219	513,525,477	531,619,487	590,098,175	651,402,374	678,211,904

[a] Monthly production estimated for bituminous coal on basis of rail shipments; for anthracite, on basis of monthly reports of Anthracite Bureau of Information.

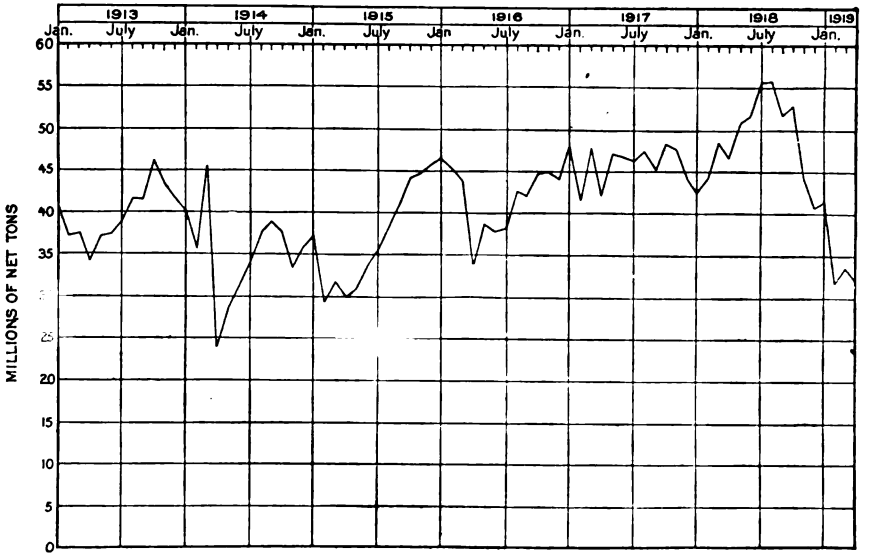

FIGURE 71.—Production of bituminous coal in the United States by months, 1913–1918.

The production of bituminous coal and anthracite in 1918, by weeks, is shown graphically in figures 4 and 5. The comparison of production by weeks shows even more clearly the fluctuation in the rate of production than the comparison by months, which is affected by the difference in the number of working days in the months.

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Bituminous coal and lignite produced in the United States in 1918, by weeks, in net tons.

Jan.	5	9,312,000	May	4	11,228,000	Sept.	7	11,069,000
	12	10,032,000		11	11,426,000		14	12,542,000
	19	8,424,000		18	11,339,000		21	12,535,000
	26	9,978,000		25	11,419,000		28	12,878,000
Feb.	2	9,492,000	June	1	10,416,000	Oct.	5	12,398,000
	9	10,424,000		8	12,401,000		12	12,190,000
	16	11,497,000		15	12,590,000		19	11,367,000
	23	10,972,000		22	11,984,000		26	11,167,000
Mar.	2	11,456,000		29	12,329,000	Nov.	2	10,716,000
	9	11,466,000	July	6	10,119,000		9	10,247,000
	16	10,908,000		13	13,114,000		16	9,598,000
	23	10,976,000		20	12,757,000		23	10,831,000
	30	10,864,000		27	12,770,000		30	9,565,000
Apr.	6	9,165,000	Aug.	3	12,383,000	Dec.	7	10,843,000
	13	10,579,000		10	12,130,000		14	10,485,000
	20	10,901,000		17	11,774,000		21	10,006,000
	27	11,569,000		24	12,472,000		28	6,343,000
				31	12,517,000			

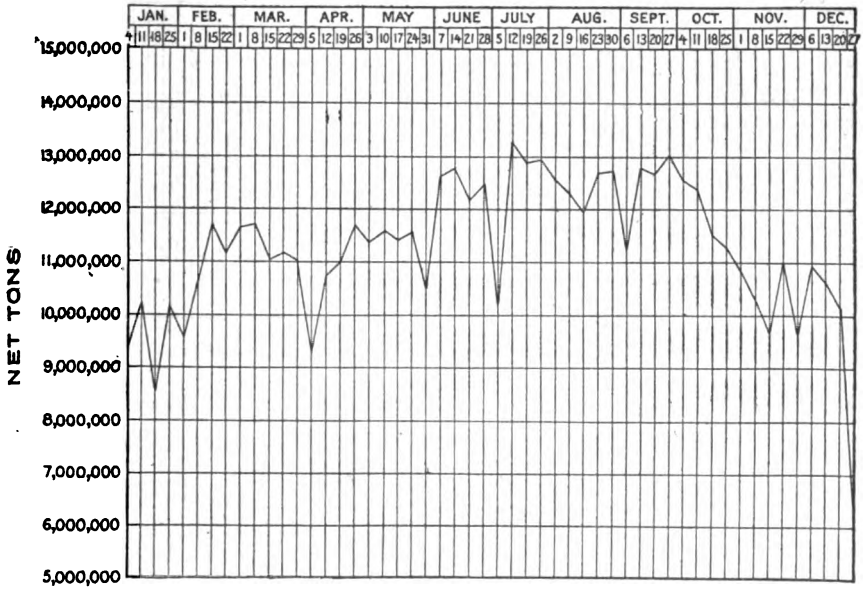

FIGURE 72.—Production of bituminous coal in the United States by weeks, 1918.

The increase in production in 1918 compared with 1917 was not shared equally by all producing fields. Among the more important producing States, Indiana, Kentucky, Ohio, Tennessee, Utah, and Wyoming each recorded gains of more than 10 per cent, whereas Alabama, Colorado, Iowa, Maryland and Texas had decreased output. The significant feature of the statistics of production for 1918 is that the eastern bituminous coal fields, in Pennsylvania, West Virginia, and Virginia, had a substantial increase in 1918 over 1917 as against the small increase in 1917 over 1916. In 1917 the largest gains were made in the middle western territory in fields not tributary to the critical eastern consuming markets, and for that reason the lack of coal in the northeastern United States was acute in 1917 and the early months of 1918.

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The increase in 1918 over 1917 in eastern Kentucky, Ohio, and Michigan, the markets for which lie mainly to the west and northwest of the mines, was 14 per cent, compared with 11.6 per cent in 1917 over 1916. In the southern fields Tennessee recorded a gain in 1918 of 10.3 per cent over 1917, as against only 0.9 per cent in 1917, whereas Alabama had a decrease of 4.4 per cent in 1918 and an increase in 1917 of 11 per cent.

The middle western fields, in Illinois, Indiana, and western Kentucky, increased by 6.4 per cent in 1918, compared with 30.7 per cent in 1917. The fields in North Dakota, Iowa, the Southwest, and Texas recorded a decrease of only 0.2 per cent in 1918, as against a gain of 16.2 per cent in 1917 over 1916. In the Rocky Mountain region the gains were 6.4 per cent in 1918 and 13.7 per cent in 1917, and in Washington 1.8 per cent and 32 per cent, respectively.

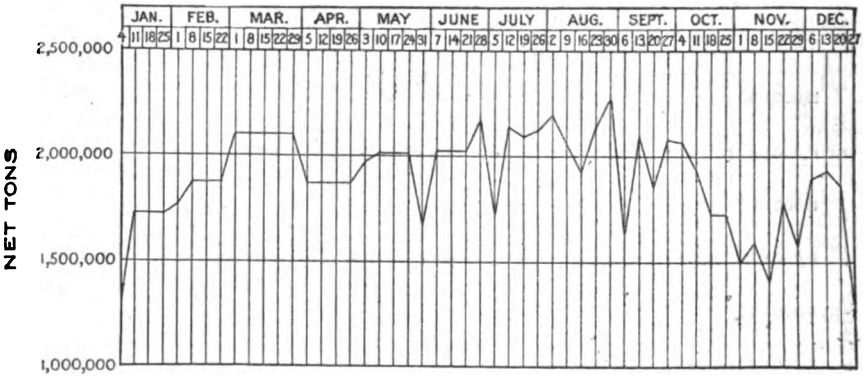

FIGURE 73.—Production of Pennsylvania anthracite, by weeks, 1918.

Bituminous coal and lignite produced in the United States, 1916–1918, by groups of States.

	Production (net tons).		Increase in 1917.		Production 1918 (net tons).	Increase or decrease in 1918.	
	1916	1917	Quantity (net tons).	Percentage.		Quantity (net tons).	Percentage.
Pennsylvania, Maryland, West Virginia, and Virginia	270,923,000	273,723,000	2,800,000	1.0	283,274,000	+ 9,551,000	+ 3.5
Eastern Kentucky, Ohio, and Michigan	53,480,000	59,693,000	6,213,000	11.6	68,068,000	+ 8,375,000	+14.0
Tennessee	6,137,000	6,194,000	57,000	.9	6,831,000	+ 637,000	+10.3
Alabama	18,086,000	20,068,000	1,982,000	11.0	19,185,000	− 883,000	− 4.4
Illinois, Indiana, and Western Kentucky	94,110,000	122,976,000	28,866,000	30.7	130,791,000	+ 7,815,000	+ 6.4
North Dakota, South Dakota, Iowa, Missouri, Kansas, Oklahoma, Arkansas, and Texas	27,119,000	31,507,000	4,388,000	16.2	31,451,000	− 56,000	− .2
Colorado, Montana, Wyoming, Utah, and New Mexico	29,388,000	33,411,000	4,023,000	13.7	35,539,000	+ 2,128,000	+ 6.4
Washington	3,039,000	4,010,000	971,000	32.0	4,082,000	+ 72,000	+ 1.8
	[a]502,282,000	551,582,000	49,300,000	9.8	579,221,000	+27,639,000	+ 5.0

[a] Does not include production in Alaska, California, Georgia, Idaho, North Carolina, and Oregon.

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Comparative statistics of production for 1917 and 1918 by fields are given in the accompanying table. The subdivisions are those adopted by the Fuel Administration for administrative purposes, each field being the unit in which a district representative was placed. These fields do not conform exactly to trade usage; as, for instance, there are six recognized trade districts in Illinois, though the Fuel Administration treated the State as one field.

Bituminous coal produced in 1917 and 1918, by districts.[a]

District.	1917	1918	Increase or decrease in 1918.
	Net tons.	*Net tons.*	*Per cent.*
Central Pennsylvania	59,044,092	61,628,709	+ 4.4
Northern Pennsylvania	7,381,328	8,051,383	+ 9.1
Pittsburgh, Pa., and Panhandle of West Virginia	50,587,769	51,554,342	+ 1.9
Westmoreland, Latrobe, Greensburg, and Ligonier	16,879,219	17,701,470	+ 4.9
Connellsville	34,596,903	35,676,500	+ 3.1
Somerset and Cumberland-Piedmont	13,843,238	14,267,225	+ 3.1
Fairmont, W. Va	17,567,575	20,104,346	+14.4
Northern Ohio	26,849,503	30,286,684	+12.8
Michigan	1,374,805	1,464,818	+ 6.5
Southern Ohio	14,098,407	15,767,536	+11.8
Northeastern Kentucky	6,453,679	7,108,816	+10.2
Hazard, Ky	1,835,353	2,364,336	+28.8
Kanawha, Logan, and Kenova-Thacker	27,864,123	30,655,180	+10.0
New River and Winding Gulf, W. Va	15,096,036	14,447,793	− 4.3
Pocahontas and Tug River, W. Va	24,947,362	23,128,235	− 7.3
Southwestern Virginia	8,604,318	9,040,792	+ 5.1
Southeastern Kentucky	6,381,144	8,082,664	+ 2.7
Tennessee and Georgia	6,313,249	6,897,764	+ 9.3
Alabama	20,068,074	19,184,962	− 4.4
Western Kentucky	10,249,480	10,833,234	+ 5.7
Indiana	26,539,329	30,678,634	+15.6
Illinois	86,199,387	89,291,105	+ 3.6
Iowa	8,965,830	8,192,195	− 8.6
Missouri	5,670,549	5,667,730	−....
Kansas	7,184,975	7,561,947	+ 5.2
Arkansas	2,143,579	2,227,369	+ 3.9
Oklahoma	4,386,844	4,813,447	+ 9.7
Texas	2,355,815	2,261,135	− 4.0
North Dakota	790,548	719,733	− 9.0
Montana and northern Wyoming	7,028,530	7,606,128	+ 8.2
Colorado	12,483,336	12,407,571	− .6
Utah and southern Wyoming	9,899,008	11,501,890	+16.2
New Mexico	4,000,527	4,023,239	+ .6
Washington	4,009,902	4,082,212	+ 1.8
	551,693,816	579,281,124	+ 5.0

[a] Does not include production in Alaska, California, Idaho, North Carolina, Oregon, and South Dakota.

The statistics of production by States in 1917 and 1918 are given in the tables on pages 707–708, which are discussed in proper sequence later in the report. In the first column of the tables the quantities loaded at the mines on railroad cars or on boats for shipment are given. Some of the coal reported under this heading, however, is shipped only a short distance and is really used locally. For instance, a considerable portion of the coal mined in the Birmingham, Ala., district is used locally by the iron and steel industry, but as the coal is loaded on railroad cars and as the tonnage appears in the statistics of movement of coal it is placed under the heading of shipped coal. A portion of the coal made into beehive coke in the mining regions is loaded on cars, and, although transported perhaps only a mile or less, is recorded as shipped coal. It should be noted that not all the coal shipped carries a freight charge or furnishes revenue for

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the railroads, as the coal for the use of the roads that enter the coal fields is nonrevenue freight.

In the second column the quantities used locally are given. Under that designation are included wagon trade, coal used by employees, coal loaded directly from the tipple into engine tenders, and that part of the product used in the immediate vicinity of the mine by such industries as brick and sewer pipe plants, power plants, and mills of various kinds. It is presumably transported from the mine to the place of consumption in the mine cars, by wagons or on private tramroads.

The coal used to generate steam and heat for the operation of the mine is shown in the third column, and that charged into coke ovens directly is given in the fourth column.

The total quantity, which is the sum of these items, represents only the usable fuel. Refuse, slate, and bone brought out of the mine or picked or sorted from the coal in the tipple and refuse from washeries and dry-cleaning plants are not considered as part of the quantity of coal produced, although the cost per ton of bringing this material to the surface is as great as that of the coal. The total value is the sum of all the values reported by the individual operators, and the average value is the total divided by the total tons.

The schedules sent out by the Geological Survey request that the total number of full days each mine was operated be given, and also the average number of employees, exclusive of office force and coke workers. The number of days a mine was operated is shown directly by the mine records, and the average number of employees is obtained by dividing the number of days into the total shifts, or "men-days," recorded in the pay rolls or time books at each operation. (See pp. 711–712.) The sum of the number of men thus reported (obtained by the Geological Survey) is considered the total for each county and State, or for the United States, as the case may be. The sum of the men-days for all mines is divided by the total number of days on which the total number of men were at work or that the mines were active.

The quantity and value of the coal produced in each State in the five years 1914–1918 and the change and percentage of change in 1918 are shown in the third of the following tables. The annual production of coal in each State from the time of earliest recorded output until the end of 1918 is given in the tabular statement in the pocket.

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Coal produced in the United States in 1917.

State.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Made into coke at mines (net tons).	Total quantity (net tons).	Total value.	Average value per ton.	Number of employees.			Average number of days worked.
								Underground.	Surface.	Total.	
Alabama	15,272,716	508,398	641,733	3,645,227	20,068,074	$45,616,992	$2.27	22,925	5,461	28,386	273
Alaska		53,955			53,955	265,317	4.92	(a)	(a)	(a)	(a)
Arkansas	2,009,408	59,104	75,067		2,143,579	5,492,777	2.56	3,135	863	3,998	187
California and Idaho	2,800	3,383	240		6,423	14,791	2.30	11	6	17	173
Colorado	9,770,529	450,392	304,492	1,957,923	12,483,336	27,669,129	2.22	11,285	2,946	14,231	263
Georgia	37,855	1,284	7,200	72,689	119,028	301,391	2.53	205	76	281	269
Illinois	80,283,345	3,541,792	2,374,250		86,199,387	162,281,822	1.88	75,085	9,005	84,090	243
Indiana	24,991,177	905,601	642,551		26,539,329	52,940,106	1.99	22,664	3,864	26,528	221
Iowa	7,954,466	784,970	226,394		8,965,830	21,096,408	2.35	12,672	1,594	14,266	251
Kansas	6,838,507	161,004	185,464		7,184,975	16,618,277	2.31	8,816	1,864	10,680	216
Kentucky	25,674,798	893,580	639,977	599,616	27,807,971	60,297,653	2.17	28,162	6,764	34,926	214
Maryland	4,582,436	104,578	58,910		4,745,924	11,667,852	2.46	4,996	1,223	5,919	254
Michigan	1,244,795	82,045	47,965		1,374,805	4,426,314	3.22	2,154	252	2,406	254
Missouri	4,942,689	576,079	151,781		5,670,549	13,755,864	2.43	7,680	1,988	9,668	240
Montana	3,882,919	176,066	167,704		4,226,689	8,919,136	2.11	3,338	811	4,149	268
New Mexico	2,927,954	44,636	36,449	991,488	4,000,527	7,455,166	1.86	3,191	935	4,126	321
North Dakota	559,571	196,900	34,077		790,548	1,425,750	1.80	619	202	821	255
Ohio	37,462,479	2,534,344	751,281	630	40,748,734	100,897,148	2.48	38,569	6,940	45,509	210
Oklahoma	4,152,162	45,492	189,190		4,386,844	12,335,413	2.81	7,017	1,478	8,495	211
Oregon	13,736	9,087	5,504		28,327	95,663	3.38	77	27	104	251
Pennsylvania (bituminous)	128,965,937	5,275,741	3,499,727	34,706,737	172,448,142	421,268,808	2.44	143,687	30,281	173,968	261
South Dakota	647	7,395			8,042	23,346	2.90	34		34	154
Tennessee	5,170,586	135,348	164,698	723,589	6,194,221	13,592,998	2.19	8,053	2,368	10,421	241
Texas	2,292,358	14,102	49,355		2,355,815	4,177,608	1.77	3,683	692	4,375	263
Utah	3,292,758	77,028	86,128	669,316	4,125,230	8,531,382	2.07	2,569	916	3,485	219
Virginia	7,733,626	173,535	145,231	2,034,699	10,087,091	20,125,713	2.00	8,607	2,561	11,168	273
Washington	3,614,329	71,606	166,399	157,568	4,009,902	10,727,362	2.68	4,072	1,240	5,312	271
West Virginia	77,996,698	2,494,393	1,194,951	4,755,625	86,441,667	200,659,368	2.32	69,155	19,267	88,422	225
Wyoming	8,179,694	125,484	270,441		8,575,619	16,593,283	1.93	6,024	1,334	7,358	246
Total bituminous	469,850,975	19,507,322	12,117,159	50,315,107	551,790,563	1,249,272,837	2.26	498,185	104,958	603,143	243
Pennsylvania anthracite	86,788,848	2,382,362	10,440,601		99,611,811	283,650,723	2.85	109,989	44,185	154,174	285
Grand total	556,639,823	21,889,684	22,557,760	50,315,107	651,402,374	1,532,923,560	2.35	608,174	149,143	757,317	251

a Not available.

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Coal produced in the United States in 1918.

State.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Made into coke at mines (net tons).	Total quantity (net tons).	Total value.	Average value per ton.	Number of employees.			Average number of days worked.
								Underground.	Surface.	Total.	
Alabama	16,061,991	304,038	593,739	2,225,194	19,184,962	$54,752,329	$2.85	20,584	5,637	26,221	278
Alaska	67,267	6,384	1,955	.....	75,606	411,850	5.45	170	69	239	254
Arkansas	2,111,992	41,457	73,920	.....	2,227,369	8,172,376	3.67	3,107	871	3,978	204
California and Idaho	5,800	600	.....	.....	6,400	17,250	2.70	10	5	15	240
Colorado	10,580,811	436,338	311,009	1,079,413	12,407,571	33,404,743	2.69	11,320	3,163	14,483	255
Georgia	21,725	888	6,250	37,853	66,716	239,377	3.59	135	55	190	258
Illinois	83,268,864	3,641,044	2,381,197	.....	89,291,105	206,860,291	2.32	75,270	10,695	85,965	238
Indiana	28,961,651	941,707	775,276	.....	30,678,634	70,384,601	2.29	23,979	6,397	30,376	227
Iowa	7,399,030	602,556	190,609	.....	8,192,195	24,703,237	3.02	11,774	1,554	13,328	245
Kansas	7,188,358	173,330	200,259	.....	7,561,947	22,028,142	2.91	8,652	2,013	10,665	234
Kentucky	29,350,941	1,049,985	678,090	583,601	31,612,617	80,666,842	2.55	30,323	9,019	39,342	230
Maryland	4,343,293	98,288	55,716	.....	4,497,297	12,466,189	2.77	4,377	1,191	5,568	261
Michigan	1,280,658	98,954	85,206	.....	1,464,818	5,615,097	3.83	2,207	351	2,558	237
Missouri	5,119,591	385,896	162,243	.....	5,667,730	17,126,498	3.02	7,644	1,946	9,590	235
Montana	4,177,894	179,079	175,532	.....	4,532,505	11,444,875	2.53	3,347	1,212	4,559	264
New Mexico	2,836,801	39,075	39,271	1,108,092	4,023,239	10,787,082	2.68	2,971	1,124	4,095	301
North Carolina	466	42	912	.....	1,420	6,745	4.75	35	15	50	40
North Dakota	526,046	173,744	19,943	.....	719,733	1,629,668	2.26	602	226	828	229
Ohio	42,888,610	2,015,720	906,613	.....	45,812,943	118,095,518	2.58	39,883	8,567	48,450	223
Oklahoma	4,567,980	37,600	207,917	.....	4,813,447	17,508,884	3.64	7,057	1,394	8,451	228
Oregon	4,112	3,946	5,270	.....	13,328	37,454	2.81	26	15	40	292
Pennsylvania (bituminous)	137,492,980	4,984,384	3,612,890	32,460,487	178,550,741	463,159,736	2.59	140,502	33,804	174,306	269
South Dakota	640	7,302	.....	.....	7,942	22,230	2.80	21	.....	21	145
Tennessee	5,904,583	148,130	181,901	596,424	6,831,048	19,305,203	2.83	8,198	2,496	10,694	265
Texas	2,204,266	11,854	45,015	.....	2,261,135	5,937,997	2.63	3,391	545	3,936	262
Utah	4,238,718	64,827	94,978	738,302	5,136,825	13,937,097	2.71	3,065	1,095	4,160	256
Virginia	8,188,502	392,712	107,519	1,601,075	10,289,808	25,865,895	2.51	8,788	2,216	11,004	277
Washington	3,659,830	74,315	193,606	154,461	4,082,212	14,132,869	3.46	3,836	1,273	5,109	275
West Virginia	81,579,916	2,636,785	1,159,951	4,559,187	89,935,839	230,508,846	2.56	69,047	20,483	89,530	238
Wyoming	9,055,252	130,777	252,659	.....	9,438,688	22,581,019	2.39	5,932	1,622	7,554	268
Total bituminous	503,068,528	18,681,757	12,521,446	45,094,089	579,385,820	1,491,809,940	2.58	496,252	119,053	615,305	249
Pennsylvania anthracite	85,927,696	2,674,439	10,223,949	.....	98,826,084	336,480,347	3.40	101,671	45,450	147,121	293
Grand total	589,016,224	21,356,196	22,745,395	45,094,089	678,211,904	1,828,290,287	2.70	597,923	164,503	762,426	258

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Coal produced in the United States, 1914–1918, and increase or decrease in 1918.

State.	1914		1915		1916		1917	
	Quantity (net tons).	Value.	Quantity (net tons).	Value.	Quantity (net tons).	Value.	Quantity (net tons).	Value.
Alabama	15,598,422	$20,349,919	14,927,987	$19,066,043	18,086,197	$24,359,831	20,068,074	$45,616,992
Arkansas	1,836,540	3,158,168	1,652,106	2,950,456	1,994,915	3,836,845	2,143,579	5,492,777
California and Alaska	a 13,974	a 39,821	a 13,903	a 35,354	a 20,313	a 67,684	a 60,378	a 280,108
Colorado	8,170,559	13,601,718	8,624,980	13,599,264	10,484,237	16,964,104	12,483,336	27,669,129
Georgia	166,498	239,462	124,496	231,861	173,554	310,093	119,028	301,391
Idaho and Nevada	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Illinois	57,589,197	64,693,529	58,829,576	64,622,471	66,195,336	82,457,954	86,199,387	162,281,822
Indiana	16,641,132	18,290,928	17,006,152	18,637,476	20,093,528	25,506,246	26,539,329	52,940,106
Iowa	7,451,022	13,364,070	7,614,143	13,577,608	7,260,800	13,530,383	8,965,830	21,096,408
Kansas	6,860,968	11,238,253	6,824,474	11,360,630	6,881,455	12,252,723	7,184,975	16,618,277
Kentucky	20,382,763	20,852,463	21,361,674	21,494,008	25,393,997	30,193,047	27,807,971	60,297,653
Maryland	4,133,547	5,234,796	4,180,477	5,330,845	4,460,046	6,947,623	4,745,924	11,667,852
Michigan	1,283,080	2,559,786	1,156,138	2,372,797	1,180,360	2,653,182	1,374,805	4,426,314
Missouri	3,935,980	6,902,325	3,811,593	6,595,918	4,742,146	9,044,505	5,670,549	13,755,864
Montana	2,805,173	4,913,191	2,789,755	4,526,509	3,632,527	6,286,197	4,226,689	8,919,126
New Mexico	3,377,689	6,230,871	3,817,940	5,481,361	3,793,011	5,580,369	4,000,527	7,455,166
North Dakota	506,685	771,379	528,078	766,072	634,912	946,082	790,548	1,425,750
Ohio	18,843,115	21,250,642	22,434,691	24,207,075	34,728,219	46,150,907	40,748,734	100,897,143
Oklahoma	3,988,613	8,204,015	3,693,580	7,435,906	3,608,011	7,525,427	4,386,844	12,335,413
Oregon	51,558	143,556	39,231	111,240	42,592	113,976	28,327	95,663
Pennsylvania (bituminous)	147,983,294	159,006,296	157,955,137	167,419,705	170,295,424	221,685,175	172,448,142	421,268,808
South Dakota	11,350	20,456	10,598	16,384	8,586	18,021	8,042	23,346
Tennessee	5,943,258	6,776,573	5,730,361	6,479,916	6,137,449	7,522,445	6,194,221	13,592,998
Texas	2,323,773	3,922,459	2,088,908	3,445,487	1,987,503	3,092,663	2,355,815	4,177,608
Utah	3,103,066	4,935,454	3,108,715	4,916,916	3,567,428	5,795,944	4,125,230	8,581,382
Virginia	7,959,535	8,032,448	8,122,596	7,962,934	9,707,474	10,261,424	10,087,091	20,125,713
Washington	3,064,320	6,751,511	2,429,095	5,276,299	3,033,588	6,907,428	4,009,902	10,727,362
West Virginia	71,707,626	71,391,408	77,184,069	74,561,349	86,460,127	102,366,092	86,441,667	200,659,368
Wyoming	6,475,293	10,063,747	6,554,028	9,555,804	7,910,647	12,239,707	8,575,619	16,593,283
Total bituminous	422,703,970	493,309,244	442,624,426	502,087,688	502,519,682	665,116,077	551,790,563	1,249,272,837
Pennsylvania anthracite	90,821,507	188,181,399	88,995,061	184,653,498	87,578,493	202,009,561	99,611,811	283,650,723
Grand total	513,525,477	681,490,643	531,619,487	686,691,186	590,098,175	867,125,638	651,402,374	1,532,923,560

a California, Idaho, and Nevada in 1914; Alaska, California, Idaho, and Nevada in 1915; and California, Alaska, and Idaho in 1916, 1917, and 1918.

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Coal produced in the United States, 1914–1918, and increase or decrease in 1918—Contd.

State.	1918		Increase or decrease, 1918 as compared with 1917.			
			Quantity.		Value.	
	Quantity (net tons).	Value.	Net tons.	Percentage.	Dollars.	Percentage.
Alabama	19,184,962	$54,752,329	− 883,112	− 4.4	+$9,135,337	+20.0
Arkansas	2,227,369	8,172,376	+ 83,790	+ 3.9	+ 2,679,599	+48.8
California and Alaska	[a] 82,006	[a] 429,100	+ [a] 21,628	+35.8	+ [a] 148,992	+53.2
Colorado	12,407,571	33,404,743	− 75,765	− .6	+ 5,735,614	+20.7
Georgia	66,716	239,377	− 52,312	−43.9	− 62,014	−20.6
Idaho and Nevada	(a)	(a)	(a)	(a)	(a)	(a)
Illinois	89,291,105	206,860,291	+3,091,718	+ 3.6	+44,578,469	+27.5
Indiana	30,678,634	70,384,601	+4,139,305	+15.6	+17,444,495	+33.0
Iowa	8,192,195	24,703,237	− 773,635	− 8.6	+ 3,606,829	+17.1
Kansas	7,561,947	22,028,142	+ 376,972	+ 5.2	+ 5,409,865	+32.6
Kentucky	31,612,617	80,666,842	+3,804,046	+13.7	+20,369,189	+33.8
Maryland	4,497,297	12,466,189	− 248,627	− 5.2	+ 798,387	+ 6.8
Michigan	1,464,818	5,615,097	+ 90,013	+ 6.5	+ 1,188,783	+26.9
Missouri	5,667,730	17,126,498	− 2,819	−.....	+ 3,370,634	+24.5
Montana	4,532,505	11,444,875	+ 305,816	+ 7.2	+ 2,525,739	+28.3
New Mexico	4,023,239	10,787,082	+ 22,712	+ .6	+ 3,331,916	+44.7
North Carolina	1,420	6,745	+ 1,420	.....	+ 6,745	.....
North Dakota	719,733	1,629,668	− 70,815	− 9.0	+ 203,918	+14.3
Ohio	45,812,943	118,095,518	+5,064,209	+12.4	+17,198,370	+17.0
Oklahoma	4,813,447	17,508,884	+ 426,603	+ 9.7	+ 5,173,471	+41.9
Oregon	13,328	37,454	− 14,999	−52.9	− 58,209	−60.8
Pennsylvania (bituminous)	178,550,741	463,159,736	+6,102,599	+ 3.5	+41,890,928	+ 9.9
South Dakota	7,942	22,230	− 100	− 1.2	− 1,116	− 4.8
Tennessee	6,831,048	19,305,203	+ 636,827	+10.3	+ 5,712,205	+42.0
Texas	2,261,135	5,937,997	− 94,680	− 4.0	+ 1,760,389	+42.1
Utah	5,136,825	13,937,097	+1,011,595	+24.5	+ 5,405,715	+63.4
Virginia	10,289,808	25,865,895	+ 202,717	+ 2.0	+ 5,740,182	+28.5
Washington	4,082,212	14,132,869	+ 72,310	+ 1.8	+ 3,405,507	+31.7
West Virginia	89,935,839	230,508,846	+3,494,172	+ 4.0	+29,849,478	+14.9
Wyoming	9,438,688	22,581,019	+ 863,069	+10.1	+ 5,987,736	+36.1
Total bituminous	579,385,820	1,491,809,940	+27,595,257	+ 5.0	+242,537,103	+19.4
Pennsylvania anthracite	98,826,084	336,480,347	− 785,727	− 0.8	+ 52,829,624	+18.6
Grand total	678,211,904	1,828,290,287	+26,809,530	+ 4.1	+295,366,727	+19.3

[a] California, Alaska, and Idaho in 1916, 1917, and 1918.

Coal produced in the United States from 1807 to 1918, inclusive, in net tons.

Year.	Pennsylvania anthracite.	Bituminous.	Total.	Year.	Pennsylvania anthracite.	Bituminous.	Total.
1807–1820	12,000	3,000	15,000	1841	1,182,441	1,108,700	2,291,141
1821	1,322	.....	1,322	1842	1,365,563	1,244,494	2,610,057
1822	4,583	54,000	58,583	1843	1,556,753	1,504,121	3,060,874
1823	8,563	60,000	68,563	1844	2,009,207	1,672,045	3,681,252
1824	13,685	67,040	80,725	1845	2,480,032	1,829,872	4,309,904
1825	42,988	75,000	117,988	1846	2,887,815	1,977,707	4,865,522
1826	59,194	88,720	147,914	1847	3,551,005	1,735,062	5,286,067
1827	78,151	94,000	172,151	1848	3,805,942	1,968,032	5,773,974
1828	95,500	100,408	195,908	1849	3,995,334	2,453,497	6,448,831
1829	138,086	102,000	240,086	1850	4,138,164	2,880,017	7,018,181
1830	215,272	104,800	320,072	1851	5,481,065	3,253,460	8,734,525
1831	217,842	120,100	337,942	1852	6,151,957	3,664,707	9,816,664
1832	447,550	146,500	594,050	1853	6,400,426	4,169,862	10,570,288
1833	600,907	133,750	734,657	1854	7,394,875	4,582,227	11,977,102
1834	464,015	136,500	600,515	1855	8,141,754	4,784,919	12,926,673
1835	690,854	134,000	824,854	1856	8,534,779	5,012,146	13,546,925
1836	842,832	142,000	984,832	1857	8,186,567	5,153,622	13,340,189
1837	1,071,151	182,500	1,253,651	1858	8,426,102	5,548,376	13,974,478
1838	910,075	445,452	1,355,527	1859	9,619,771	6,013,404	15,633,175
1839	1,008,322	552,038	1,560,360	1860	8,115,842	6,494,200	14,610,042
1840	967,108	1,102,931	2,070,039				

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Coal produced in the United States from 1807 to 1918, inclusive, net tons—Continued.

Year.	Pennsylvania anthracite	Bituminous.	Total.	Year.	Pennsylvania anthracite.	Bituminous.	Total.
1861.....	9,799,654	6,688,358	16,488,012	1891.....	50,665,431	117,901,238	168,566,669
1862.....	9,695,110	7,790,725	17,485,835	1892.....	52,472,504	126,856,567	179,329,071
1863.....	11,785,320	9,533,742	21,319,062	1893.....	53,967,543	128,385,231	182,352,774
1864.....	12,538,649	11,066,474	23,605,123	1894.....	51,921,121	118,820,405	170,741,526
1865.....	11,891,746	11,900,427	23,792,173	1895.....	57,999,337	135,118,193	193,117,530
1866.....	15,651,183	13,352,400	29,003,583	1896.....	54,346,081	137,640,276	191,986,357
1867.....	16,002,109	14,722,313	30,724,422	1897.....	52,611,680	147,617,519	200,229,199
1868.....	17,003,405	15,858,555	32,861,960	1898.....	53,382,644	166,593,623	219,976,267
1869.....	17,083,134	15,821,226	32,904,360	1899.....	60,418,005	193,323,187	253,741,192
1870.....	15,664,275	17,371,305	33,035,580	1900.....	57,367,915	212,316,112	269,684,027
1871.....	19,342,057	27,543,023	46,885,080	1901.....	67,471,667	225,828,149	293,299,816
1872.....	24,233,166	27,220,233	51,453,399	1902.....	41,373,595	260,216,844	301,590,439
1873.....	26,152,837	31,449,643	57,602,480	1903.....	74,607,068	282,749,348	357,356,416
1874.....	24,818,790	27,787,130	52,605,920	1904.....	73,156,709	278,659,689	351,816,398
1875.....	22,485,766	29,862,554	52,348,320	1905.....	77,659,850	315,062,785	392,722,635
1876.....	22,793,245	30,486,755	53,280,000	1906.....	71,262,411	342,874,867	414,157,278
1877.....	25,660,316	34,841,444	60,501,760	1907.....	85,604,312	394,759,112	480,363,424
1878.....	21,689,682	36,245,918	57,935,600	1908.....	83,268,754	332,573,944	415,842,698
1879.....	30,207,793	37,898,006	68,105,799	1909.....	81,070,359	379,744,257	460,814,616
1880.....	28,649,812	42,831,758	71,481,570	1910.....	84,485,236	417,111,142	501,596,378
1881.....	31,920,018	53,961,012	85,881,030	1911.....	90,464,097	405,907,059	496,371,180
1882.....	35,121,256	68,429,933	103,551,189	1912.....	84,361,598	450,104,982	534,466,561
1883.....	38,456,845	77,250,680	115,707,525	1913.....	91,524,922	478,435,297	569,960,219
1884.....	37,156,847	82,998,704	120,155,551	1914.....	90,821,507	422,703,970	513,525,477
1885.....	38,335,974	72,824,321	111,160,295	1915.....	88,996,061	442,624,426	531,619,487
1886.....	39,035,446	74,644,981	113,680,427	1916.....	87,578,493	502,519,682	590,098,175
1887.....	42,088,197	88,562,314	130,650,511	1917.....	99,611,811	551,790,563	651,402,374
1888.....	46,619,564	102,040,093	148,659,657	1918.....	98,826,084	579,385,820	678,211,904
1889.....	45,546,970	95,682,543	141,229,513				
1890.....	46,468,641	111,302,322	157,770,963		2,912,528,966	9,896,488,388	12,809,017,354

LABOR STATISTICS.

Labor is one of the four factors that are essential in order to provide a supply of coal sufficient for the country's needs, the other factors being reserves, developed mines, and transportation; and labor is one of the four factors that may limit the production of coal, the other three being transportation disability, mine disability, and lack of market.

The United States went through the war and produced coal in quantities never before attained, without shortage of mine labor. It is well, however, to examine the statistics of mine labor in order to ascertain the tendency, if any, in the direction of a shortage and to consider the probable effect of such a shortage on future production. The often reiterated statements of individual coal operators that they are experiencing labor shortage and their complaints that labor shortage is reducing output need explanation, in view of the fact that the total number of men employed in the production of coal in 1918 has been exceeded but once, in 1914.

Conditions with respect to supply of labor in the past few years have been different, however, in the anthracite and the bituminous coal regions. The number of men employed in the production of Pennsylvania anthracite has been steadily decreasing since 1914. In 1900 there were 144,206 men reported in the anthracite region, and the number increased steadily to 179,679 men in 1914, but decreased to 147,121 in 1918. A decrease of 18 per cent in number of men in four years certainly indicates a shortage of labor.

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In the bituminous coal regions the total number of men reached a maximum in 1918 of 615,000 men, compared with the previous high records of 603,000 in 1917 and 583,500 in 1914. In the face of these returns there does not appear to have been a shortage of mine labor in 1917 or 1918 in the bituminous regions, at least from a national viewpoint. It remains to inquire to what extent the apparent shortage of labor in the anthracite region affected output and whether there may be any factor in the labor situation in the bituminous regions that is not disclosed in a consideration of the total number of men employed and that has limited or may limit production.

It is well to note first the method by which the Geological Survey obtains the statistics of labor and then to inquire as to the limitations of these statistics. The annual schedules on which operators of coal mines report production and other statistics to the Geological Survey ask the following questions as to men employed:

Total number of full days mine (tipple) was in operation during the year. (Parts of days should be reduced to equivalent in full days) ....
Average number of men employed during the year, excluding coke workers and office force:
Underground..... .....
Surface..... .....

The number of days of operation for a given mine is a matter of record and may easily be determined from the mine records. To determine at all accurately the average number of men employed in the year it is necessary to add the number of man-days of labor and divide the total by the number of days the mine worked. The number of man-days is ascertained by adding for each pay period the number of shifts—that is, one man's work for one day—and making a total for the year of all such subtotals. Unless very detailed records are maintained it is necessary to assume that contract laborers—as miners—work a full day each day they enter the mine. The part days of day-pay labor are taken care of by the pay roll, for part days are paid for as such.

In all probability some operators collect the figures for the Geological Survey by adding the totals of men on the pay roll by pay periods. That will inflate the statistics to the extent that the same employee may appear on the pay rolls of two or more operations in the same period—that is, that factor will introduce duplication in proportion to the rapidity of labor turnover. There is nothing in the nature of the returns to indicate the relative accuracy of the original data, nor does a study of the statistics disclose anything to indicate that they are other than relatively accurate and present a true picture of conditions.

The two sets of figures reported for each mine—days and men—are multiplied together, and the sums of the products for each county, State, and the United States are divided by the respective sums of men employed to determine the average days worked. These data have their limitations. They are not accurate in all details, but they are comparable from year to year for each unit of the industry and represent the best figures obtainable under present comditions, both as to records generally available at mine offices and as to the funds allotted to the Geological Survey for their collection.

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STATISTICS OF LABOR IN THE ANTHRACITE REGION.

The supply of labor available for the production of Pennsylvania anthracite decreased notably in the period from 1914 to 1918—from 179,679 to 147,121 men, or 18 per cent. Production in that period increased from 90,821,507 to 98,826,084 net tons, or nearly 9 per cent. From 1917 to 1918 the number of men employed decreased by 4.5 per cent, while production decreased but 0.8 per cent.

It is thus made apparent that in the anthracite region, where the number of men has actually decreased in recent years, production, though limited in 1917 and 1918 below the demand, has increased. It should be stated here that in 1917 and 1918 only one factor—labor supply—limited the output of Pennsylvania anthracite, that the demand throughout the two years was in excess of the supply, and that there was no lack of transportation for anthracite.

Production is dependent not only on the number of men employed but on the number of days the men work. The increase in production from 1914 to 1918 with a decreasing supply of labor was made possible by an increase in the number of days of work. In 1914 the 179,679 men worked an average of 245 days; in 1918 the 147,121 men worked an average of 293 days, a gain of 19.5 per cent, which tended to offset the decrease of 18 per cent in the number of men.

That nearly full-time operation of the anthracite mines was attained in 1918 (293 days out of a theoretical year of 304 working days) shows that the practical limit of production with the labor available was reached. Each year the cost in labor increases because of the greater depths and thinner beds of coal that have to be mined, and therefore no increase in production can be had, nor can even the present production be maintained without a substantial increase over the number of men available in 1917 and 1918.

STATISTICS OF LABOR IN THE BITUMINOUS COAL REGIONS.

The total number of men employed in the production of bituminous coal reached the large total of 615,000 in 1918, exceeding all previous records. With this number of men working an average of 249 days, the unprecedented total of nearly 580,000,000 tons of bituminous coal was produced. Had there been need for a greater quantity of bituminous coal, and had the railroads been able to furnish transportation in excess of what was supplied, those 615,000 men could have worked more days, for there are 304 possible working days in a year. From the national standpoint, therefore, it is plain that no shortage of labor existed in the bituminous coal regions in 1918.

There were complaints of labor shortage in 1918 from several districts and from many mines. Such complaints of labor shortage are made regularly and currently from all fields and indicate a situation that is separate and distinct from labor shortage as considered from the national viewpoint. Before attempting to define labor shortage it is necessary to explain the intimate relation between car supply and labor supply, for in that relation is found the reason for common and current declarations of labor shortage by operators of coal mines.

Four causes of the nonoperation of a coal mine are recognized—lack of transportation to carry the coal to market, lack of labor to operate the mine, physical disability in or about the mine preventing

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its operation, and lack of market for the coal. Except in periods of general strikes, as in Ohio and Colorado in 1914, lack of men to operate mines is a small factor, for, although the number of men may be less than is desired by any particular operator or group of operators, sufficient numbers of men to justify operation are usually available. Mine disability is not of large moment as a cause of nonoperation; it ranges from 3 to 4 per cent over long periods of time, and except for such disasters as the Cabin Creek flood in August, 1916, does not generally afflict all mines simultaneously.

The mine operator is in the business of producing and selling coal. Experience has shown that one or the other of two impelling causes operates to prevent his fullest realization of that purpose—lack of market or lack of transportation. Lack of market means that the operator is not able to sell all the coal he can produce and would like to sell. In such periods of no demand mines are idle, some for weeks at a time, others for days each week. The demand for coal produced in Indiana in 1916, for instance, was so light that during the summer the mines were idle the greater part of the time and for the year they averaged only 187 days of work.

However, experience has shown that when demand is good and all the producers, or the majority of them have orders for coal that would require the operation of the mines on full time, six days a week, the railroads are not able to meet the demands for cars and transportation—that is, the railroads are not developed and equipped to the point where they can meet the peak of the load. At such times the combined orders of all operators for cars in which to load coal exceed the number of cars that can be supplied daily by the railroads. When such a condition exists the operator can sell all the coal he can produce, usually, in part at least, at an enhanced price. His profits in such times are measured by the number of cars he may be able to have placed at his mines.

When the number of cars ordered by operators for loading coal equals or exceeds the number that from day to day the railroads can furnish, the railroads prorate the available supply among the mines. The basis for this distribution is the relative capacity of the mines to produce and load coal, which is expressed in the "car ratings" established by the railroads. Thus the supply of cars received at each mine at the time when the operator has the greatest desire for the cars depends upon the mine rating.

As just stated, the mine rating is determined by the capacity of the mine to produce and load coal. Anything an operator may do to increase this capacity will therefore increase his rating and thereby insure him a larger share of the cars available on his railroad. For example, if the combined ratings of mines on a railroad division are 100 cars per day, and the number of cars on that division available for placement at the mines for coal loading on a given day is 80, each mine is entitled to 80 per cent of its rating in cars. If there are 10 mines on this division, each rated at 10 cars per day, each mine is entitled to 8 cars from the total of 80. If one operator by adding to his supply of labor can increase the hourly rate of output by, say, 20 per cent, his rating will be increased to 12 cars per day and his share of the total cars available will thereafter be 20 per cent greater than before. As it is generally true that the mines are developed beyond the present labor supply, the desire to obtain more men and increase

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output in times of car shortage is logical and warranted. Individual operators can correctly say that they are short of labor. The point that must be clearly understood is that increases in employees in one or many mines will not at such times and under the conditions described increase the total production of coal. In the assumed case just cited, no matter to what extent one or several of the operators might increase the capacity of their mines by adding to this number of men, there would be only the 80 cars to be loaded by the mines on that particular railroad division.

As between coal-producing districts or fields there may be relative shortages of labor. A district such as that about Pittsburgh, Pa., may have at times, as in 1917 and 1918, undergone a material decrease in the number of men employed in the production of coal because of the nearness of other industries able to offer inducements in the way of higher pay or shorter hours. Just as cars are distributed between mines on a division of a railroad in accordance with the mine ratings, so are cars divided between divisions as a whole on a railroad in accordance with the total ratings of mines on the separate divisions. A general increase or decrease in labor supply and consequently in the capacity and rating of a district will therefore in time affect the car supply received by the district. Thus labor supply affects car supply.

On the other hand, car supply affects labor supply. A continued acute shortage of cars in a district means a corresponding loss of production and enforced idleness of labor. Such enforced idleness causes men to leave the field, and as loss of labor reduces capacity the railroad ratings are decreased. A continuous cycle of causes and effects, car shortage reducing labor supply and labor shortage reducing car supply is at work in all periods of good market for coal.

There is another phase of the labor supply that is not disclosed in the preceding discussion. In the following table the number and percentages of inside and outside employees as reported to the Geological Survey for 1916, 1917, and 1918 are shown. In those three years the total number of men employed in the production of bituminous coal increased from 561,000 to 615,000, or about 10 per cent, but the number of men employed inside increased only from 474,000 to 496,000, or 4.6 per cent. In 1916, of the total number of employees, 84.5 per cent were underground, in 1917 82.6 per cent, and in 1918 only 80.7 per cent. The same condition is reflected in the anthracite region of Pennsylvania, where the percentage of inside labor to the total decreased from 73.0 in 1916 to 71.3 in 1917 and to 69.1 in 1918. The explanation of this proportionately greater increase in outside labor (offered to the writer by those familiar with conditions at the mines) is that the years 1917 and 1918 were both periods of successively greater demand; that operators, in their efforts to increase the number of men at their mines and thereby their capacity, car rating, and car supply, added to their forces any and all labor obtainable; and that a large proportion of the new men could not be used underground and were therefore put at work on the surface. With the return of a dull market in the later part of 1918 and the first half of 1919 it was to be expected that a considerable portion of the extra labor represented in these outside employees should be laid off and that the year 1919 should show a relative decrease in the number of laborers of that class at the mines.

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Men employed in the coal mines of the United States in 1916, 1917, and 1918.

State.	Underground.		Surface.		Total.
	Number.	Percentage	Number.	Percentage.	
1916.					
Alabama	21,453	84.8	3,855	15.2	25,308
Alaska	69	83.1	14	16.9	83
Arkansas	3,055	81.0	717	19.0	3,772
California and Idaho	11	61.1	7	38.9	18
Colorado	10,456	79.8	2,648	20.2	13,104
Georgia	322	78.3	89	21.7	411
Illinois	68,127	90.2	7,411	9.8	75,538
Indiana	20,992	87.6	2,973	12.4	23,965
Iowa	12,960	89.7	1,483	10.3	14,443
Kansas	10,325	85.1	1,807	14.9	12,132
Kentucky	26,501	84.9	4,721	15.1	31,222
Maryland	4,719	83.8	914	16.2	5,633
Michigan	2,124	83.8	411	16.2	2,535
Missouri	7,877	81.6	1,777	18.4	9,654
Montana	3,065	81.1	716	18.9	3,781
New Mexico	3,304	73.1	1,218	26.9	4,522
North Carolina					
North Dakota	553	77.5	161	22.5	714
Ohio	36,680	88.6	4,714	11.4	41,394
Oklahoma	6,620	84.9	1,180	15.1	7,800
Oregon	78	73.6	28	26.4	106
Pennsylvania (bituminous)	139,186	82.7	29,026	17.3	168,212
South Dakota	26	68.4	12	31.6	38
Tennessee	7,661	83.2	1,550	16.8	9,211
Texas	3,901	87.1	580	12.9	4,481
Utah	2,397	76.6	732	23.4	3,129
Virginia	7,359	75.3	2,418	24.7	9,777
Washington	3,764	78.5	1,033	21.5	4,797
West Virginia	64,618	82.8	13,449	17.2	78,067
Wyoming	6,041	83.3	1,214	16.7	7,255
Total bituminous	474,244	84.5	86,858	15.5	561,102
Pennsylvania anthracite	116,705	73.0	43,164	27.0	159,869
Grand total	590,949	82.0	130,022	18.0	720,971
1917.					
Alabama	22,925	80.8	5,461	19.2	28,386
Alaska	(a)		(a)		(a)
Arkansas	3,135	78.4	863	21.6	3,998
California and Idaho	11	64.7	6	35.3	17
Colorado	11,285	79.3	2,946	20.7	14,231
Georgia	205	73.0	76	27.0	281
Illinois	75,085	89.3	9,005	10.7	84,090
Indiana	22,664	85.4	3,864	14.6	26,528
Iowa	12,672	88.8	1,594	11.2	14,266
Kansas	8,816	82.5	1,864	17.5	10,680
Kentucky	28,162	80.6	6,764	19.4	34,926
Maryland	4,696	79.3	1,223	20.7	5,919
Michigan	2,154	89.5	252	10.5	2,406
Missouri	7,680	79.4	1,988	20.6	9,668
Montana	3,338	80.5	811	19.5	4,149
New Mexico	3,191	77.3	935	22.7	4,126
North Carolina					
North Dakota	619	75.4	202	24.6	821
Ohio	38,569	84.8	6,940	15.2	45,509
Oklahoma	7,017	82.6	1,478	17.4	8,495
Oregon	77	74.0	27	26.0	104
Pennsylvania (bituminous)	143,687	82.6	30,281	17.4	173,968
South Dakota	34	100.0			34
Tennessee	8,053	77.3	2,368	22.7	10,421
Texas	3,683	84.2	692	15.8	4,375
Utah	2,569	73.7	916	26.3	3,485
Virginia	8,607	77.1	2,561	22.9	11,168
Washington	4,072	76.7	1,240	23.3	5,312
West Virginia	69,155	78.2	19,267	21.8	88,422
Wyoming	6,024	81.9	1,334	18.1	7,358
Total bituminous	498,185	82.6	104,958	17.4	603,143
Pennsylvania anthracite	109,989	71.3	44,185	28.7	154,174
Grand total	608,174	80.3	149,143	19.7	757,317

(a) Not available.

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Men employed in the coal mines of the United States in 1916, 1917 and 1918—Contd.

State.	Underground.		Surface.		Total.
	Number.	Percentage.	Number.	Percentage.	
1918.					
Alabama	20,584	78.5	5,637	21.5	26,221
Alaska	170	71.1	69	28.9	239
Arkansas	3,107	78.1	871	21.9	3,978
California and Idaho	10	66.7	5	33.3	15
Colorado	11,320	78.2	3,163	21.8	14,483
Georgia	135	71.1	55	28.9	190
Illinois	75,270	87.6	10,695	12.4	85,965
Indiana	23,979	78.9	6,397	21.1	30,376
Iowa	11,774	88.3	1,554	11.7	13,328
Kansas	8,652	81.1	2,013	18.9	10,665
Kentucky	30,323	77.1	9,019	22.9	39,342
Maryland	4,377	78.6	1,191	21.4	5,568
Michigan	2,207	86.3	351	13.7	2,558
Missouri	7,644	79.7	1,946	20.3	9,590
Montana	3,347	73.4	1,212	26.6	4,559
New Mexico	2,971	72.6	1,124	27.4	4,095
North Carolina	35	70.0	15	30.0	50
North Dakota	602	72.7	226	27.3	828
Ohio	39,883	82.3	8,567	17.7	48,450
Oklahoma	7,057	83.5	1,394	16.5	8,451
Oregon	25	62.5	15	37.5	40
Pennsylvania (bituminous)	140,502	80.6	33,804	19.4	174,306
South Dakota	21	100.0			21
Tennessee	8,198	76.7	2,496	23.3	10,694
Texas	3,391	86.2	545	13.8	3,936
Utah	3,065	73.7	1,095	26.3	4,160
Virginia	8,788	79.9	2,216	20.1	11,004
Washington	3,836	75.1	1,273	24.9	5,109
West Virginia	69,047	77.1	20,483	22.9	89,530
Wyoming	5,932	78.5	1,622	21.5	7,554
Total bituminous	496,252	80.7	119,053	19.3	615,305
Pennsylvania anthracite	101,671	69.1	45,450	30.9	147,121
Grand total	597,923	78.4	164,503	21.6	762,426

Coal produced per man employed, 1890–1918.

Year.	Anthracite.				Bituminous.			
	Men employed.	Days worked.	Average tonnage per man per day.	Average tonnage per man per year.	Men employed.	Days worked.	Average tonnage per man per day.	Average tonnage per man per year.
1890	126,000	200	1.85	369	192,204	226	2.56	579
1891	126,350	203	1.98	401	205,803	233	2.57	573
1892	129,050	198	2.06	407	212,893	219	2.72	596
1893	132,944	197	2.06	406	230,365	204	2.73	557
1894	131,603	190	2.08	395	244,603	171	2.84	486
1895	142,917	196	2.07	406	239,962	194	2.90	563
1896	148,991	174	2.10	365	244,171	192	2.94	564
1897	149,884	150	2.34	351	247,817	196	3.04	596
1898	145,504	152	2.41	367	255,717	211	3.09	651
1899	139,608	173	2.50	433	271,027	234	3.05	713
1900	144,206	166	2.40	398	304,375	234	2.98	697
1901	145,309	196	2.37	464	340,235	225	2.94	664
1902	148,141	116	2.40	279	370,056	230	3.06	703
1903	150,483	206	2.41	496	415,777	225	3.02	680
1904	155,861	200	2.35	469	437,832	202	3.15	637
1905	165,406	215	2.18	470	460,629	211	3.24	684
1906	162,355	195	2.25	439	478,425	213	3.36	717
1907	167,234	220	2.33	512	513,258	234	3.29	769
1908	174,174	200	2.39	478	516,264	193	3.34	644
1910	169,497	229	2.17	498	555,533	217	3.46	751
1911	172,585	246	2.13	524	549,775	211	3.50	738
1912	174,030	231	2.10	485	548,632	223	3.68	820
1913	175,745	257	2.02	520	571,882	232	3.61	837
1914	179,679	245	2.06	505	583,506	195	3.71	724
1915	176,552	230	2.19	504	557,456	208	3.91	794
1916	159,869	253	2.16	548	561,102	230	3.90	896
1917	154,174	285	2.27	646	603,143	243	3.77	915
1918	147,121	293	2.29	672	615,305	249	3.78	942

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Coal produced per man and average number of days per year in 1917 and 1918.

State.	1917			1918		
	Days worked.	Average tonnage.		Days worked.	Average tonnage.	
		Per year.	Per day.		Per year.	Per day.
Alabama	273	707	2.59	278	732	2.63
Arkansas	187	536	2.87	204	560	2.75
Colorado	263	877	3.33	255	857	3.36
Illinois	243	1,025	4.22	238	1,039	4.37
Indiana	221	1,000	4.52	227	1,010	4.45
Iowa	251	628	2.50	245	615	2.51
Kansas	216	673	3.12	234	709	3.03
Kentucky	214	796	3.72	230	804	3.50
Maryland	254	802	3.16	261	806	3.10
Michigan	254	571	2.25	237	573	2.42
Missouri	240	587	2.44	235	591	2.51
Montana	268	1,019	3.80	264	994	3.77
New Mexico	321	970	3.02	301	982	3.26
North Dakota	255	963	3.78	229	869	3.79
Ohio	210	895	4.26	223	946	4.24
Oklahoma	211	516	2.45	228	570	2.50
Pennsylvania:						
Anthracite	285	646	2.27	293	672	2.29
Bituminous	261	991	3.80	269	1,024	3.81
Tennessee	241	594	2.46	265	639	2.41
Texas	263	538	2.05	262	574	2.19
Utah	219	1,184	5.40	258	1,235	4.79
Virginia	273	903	3.31	277	935	3.38
Washington	271	755	2.79	275	799	2.91
West Virginia	225	978	4.35	238	1,005	4.22
Wyoming	246	1,165	4.74	268	1,249	4.66

Statistics of labor employed in coal mines of the United States, 1914–1917.

State.	1914		1915		1916		1917		1918	
	Number of days active.	Average number employed.	Number of days active.	Average number employed.	Number of days active.	Average number employed.	Number of days active.	Average number employed.	Number of days active.	Average number employed.
Alabama	226	24,042	223	22,591	262	25,308	273	28,386	278	26,221
Alaska	(a)	(a)	(a)	(a)	179	83	(a)	(a)	254	239
Arkansas	143	4,339	149	3,751	184	3,772	187	3,998	204	3,978
California	b291	b43	b285	b36	b188	b18	b173	b17	b240	b15
Colorado	244	10,098	194	12,372	233	13,104	263	14,231	255	14,483
Georgia	207	355	197	368	280	411	269	281	258	190
Idaho	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)
Illinois	173	79,499	179	75,610	198	75,538	243	84,090	238	85,965
Indiana	168	23,175	179	22,777	187	23,965	221	26,528	227	30,376
Iowa	204	16,057	220	15,549	202	14,443	251	14,266	245	13,328
Kansas	192	12,448	184	13,260	204	12,132	216	10,680	234	10,665
Kentucky	187	28,764	186	27,960	208	31,222	214	34,926	230	39,342
Maryland	241	5,403	242	5,664	256	5,633	254	5,919	261	5,568
Michigan	201	2,800	198	2,569	216	2,535	254	2,406	237	2,558
Missouri	179	9,549	186	9,173	207	9,654	240	9,668	235	9,590
Montana	209	3,350	201	3,158	244	3,781	268	4,149	264	4,559
New Mexico	283	4,178	262	4,205	292	4,522	321	4,126	301	4,095
North Carolina									40	50
North Dakota	216	558	219	590	244	714	255	821	229	828
Ohio	108	45,401	142	40,053	197	41,394	210	45,509	223	48,450
Oklahoma	205	8,078	167	8,457	178	7,800	211	8,495	228	8,451
Oregon	266	190	206	151	236	106	251	104	292	40
Pennsylvania (bituminous)	214	184,201	226	174,593	259	168,212	261	173,968	269	174,306
South Dakota	152	47	155	35	145	38	154	34	145	21
Tennessee	220	10,116	220	8,948	239	9,211	241	10,421	265	10,694
Texas	237	4,635	233	5,087	218	4,481	263	4,375	262	3,936
Utah	210	4,112	208	3,564	228	3,129	219	3,485	258	4,160
Virginia	235	9,183	235	8,959	272	9,777	273	11,168	277	11,004
Washington	191	5,805	169	4,850	217	4,797	271	5,312	275	5,109
West Virginia	201	78,963	208	75,882	237	78,067	225	88,422	238	89,530
Wyoming	192	8,117	201	7,244	248	7,255	246	7,358	268	7,554
Total bituminous	195	583,506	203	557,456	230	561,102	243	603,143	249	615,305
Pennsylvania (anthracite)	245	179,679	230	176,552	253	159,869	285	154,174	293	147,121
Grand total	207	763,185	209	734,008	235	720,971	251	757,317	258	762,426

a Number of men not reported.
b California includes Idaho and Nevada in 1914 and 1915; Idaho in 1916, 1917, and 1918.

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The United States Fuel Administration made an investigation of the labor supply at coal mines along somewhat different lines than those covered by the annual statistics of the Geological Survey. The operators of coal mines were requested to furnish data showing the number of men on the pay roll at certain dates, classified as follows:[1]

Underground:
- Miners and loaders.
- Cutters.
- Motor men, pump men, electricians, and others mechanically employed underground.
- All others.

Surface.

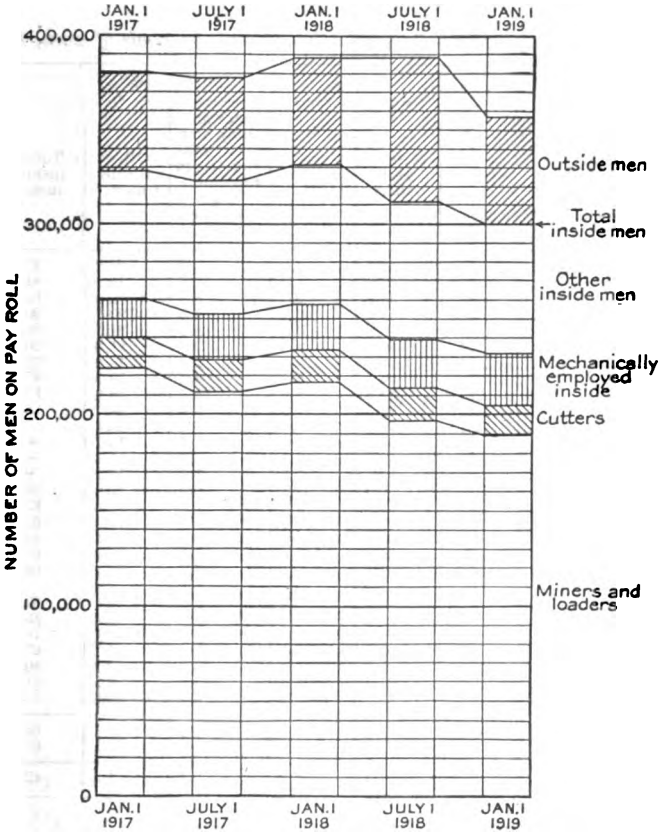

FIGURE 74.—Number of men on the pay rolls of 3,061 bituminous coal mines in the United States at 6-month intervals from January 1, 1917, to January 1, 1919, by classes of labor performed.

The dates covered were January 1, 1917; July 1, 1917; January 1, 1918; July 1, 1918; and January 1, 1919. In tabulating these statistics only such reports were included as were comparable for all the dates given. A number of causes thus prevented the inclusion of all the reports furnished, and the totals therefore do not cover all operations, but they are strictly comparable. These statistics

[1] This classification was made by Mr. S. A. Taylor, of Pittsburgh, Pa., consulting mining engineer of the Fuel Administration.

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in detail are contained in Part III of the report of the distribution division of the Fuel Administration. The following table, which is based on these statistics, shows the percentages of labor by the classification noted. Miners, loaders, and cutters, the men actually getting out the coal, represent about 60 per cent of the total labor in the bituminous coal mines and only about 45 per cent of the labor in the anthracite mines. The percentage of surface or outside men at bituminous coal mines reported in these statistics, 14.6 per cent of the total, is below that reported in the annual statistics of the Geological Survey—17.4 per cent in 1917 and 19.3 per cent in 1918—but the percentage reported for the anthracite mines, 31.3 per cent, is higher than that reported to the Geological Survey—28.7 per cent in 1917 and 30.9 per cent in 1918.

Percentages of men employed in the production of coal, by kinds of work, 1917–18.

State.	Inside men.					Outside men.
	Miners and loaders.	Cutters.	Motor men, pump men, electricians, and others mechanically employed inside.	Other inside men.	Total inside men.	
Alabama	55.0	2.2	5.2	21.1	83.5	16.5
Arkansas	58.4	.3	14.5	10.9	84.1	15.9
Colorado	55.9	2.7	4.4	19.5	82.5	17.5
Illinois	61.0	4.7	4.3	20.7	90.7	9.3
Indiana	59.0	4.1	5.6	21.7	90.4	9.6
Iowa	65.5	1.1	2.7	21.0	90.3	9.7
Kansas	72.3	.2	7.2	13.6	93.3	6.7
Kentucky	49.1	5.6	8.4	19.8	82.9	17.1
Maryland	59.8	1.0	5.0	16.3	82.1	17.9
Michigan	52.0	7.2	5.0	24.7	88.9	11.1
Missouri	66.7	7.4	2.4	16.0	92.5	7.5
Montana	51.7	4.2	4.8	19.7	80.4	19.6
New Mexico	53.4	2.1	3.6	17.3	76.4	23.6
North Dakota	51.6	7.0	3.5	16.9	79.0	21.0
Ohio	58.3	7.1	6.3	17.1	88.8	11.2
Oklahoma	55.3	4.3	2.0	25.6	87.2	12.8
Oregon	40.0	.....	6.2	17.3	63.5	36.5
Pennsylvania bituminous, total	55.3	4.6	6.9	17.8	84.6	15.4
Central Pennsylvania	62.7	2.8	5.9	14.0	85.4	14.6
Western and southwestern Pennsylvania	50.3	5.8	7.5	20.5	84.1	15.9
Tennessee	56.4	.9	6.5	18.4	82.2	17.8
Texas	67.8	.1	2.6	16.3	86.8	13.2
Utah	49.8	3.2	6.9	16.6	76.5	23.5
Virginia	47.9	3.0	12.9	17.2	81.0	19.0
Washington	41.0	.4	25.4	13.7	80.5	19.5
West Virginia	46.4	4.4	10.3	20.3	81.4	18.6
Wyoming	53.9	2.8	4.2	19.8	80.7	19.3
Total bituminous	55.4	4.3	6.6	19.1	85.4	14.6
Pennsylvania anthracite	43.3	1.5	3.8	20.1	68.7	31.3
Total	53.1	3.7	6.1	19.3	82.2	17.8

The diagram (fig. 74) shows graphically the changes by 6-month intervals in the number of men employed in the production of bituminous coal as reported by the operators of 3.081 mines, employing about 60 per cent of the total labor engaged.

Throughout the war the total supply of labor was maintained, the number on the pay rolls at these 3,081 mines in 1918 exceeding the number in 1917. It is significant, however, that the number of miners, loaders, and cutters, the employees that actually produce the coal, decreased in the 2-year period covered by these statistics. The comparative record for January, 1919, showing sharp decreases, can not be held to be of special significance, because at that time

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the bituminous trade was passing through a period of unusual winter inactivity. One of the first effects of this slump in business, it is apparent, was the release of extra outside or surface men.

It is evident that the combined effects of the recruiting of mine laborers by other industries and by the Army, either by voluntary enlistment or through the draft, took from the mines the younger and more energetic men, those most active in the production of coal. A continuation of this tendency of decrease in underground workers would in time seriously impair the capacity of the bituminous industry. It can not be said to have done so yet, however, What the course of future events may bring about in the supply of mine labor, through greater emigration of our miners to their home countries abroad and through lack of the acquisition of new hands by immigra-

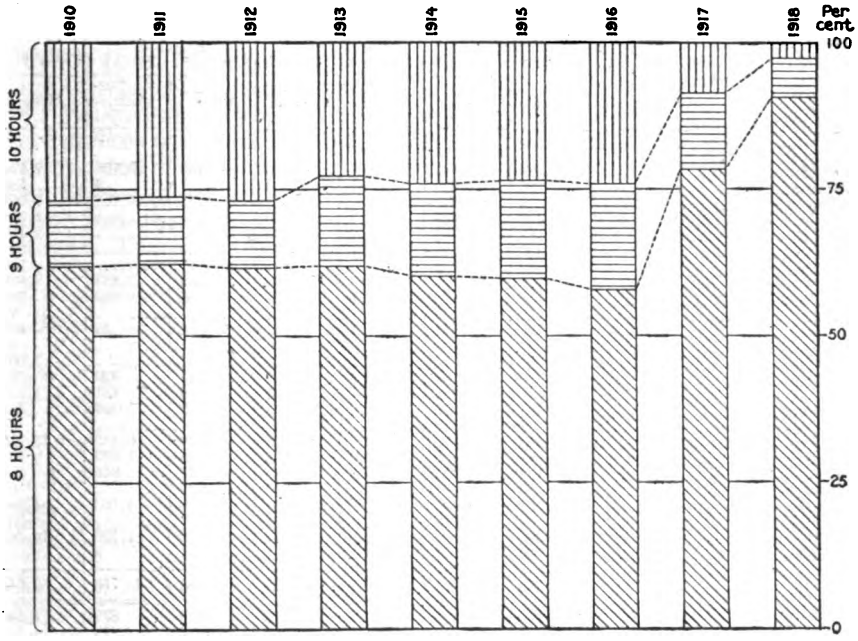

FIGURE 75.—Percentage of labor in bituminous coal mines with established working days of 8, 9, and 10 hours, 1910–1918.

tion, together with losses by desertion to other industries that offer opportunities for more continuous employment than are offered in normal years by the bituminous coal industry, is a present field for speculation.

Further progress in the adoption of the 8-hour working day in the bituminous coal mines was made in 1918. According to the reports made to the Geological Survey, the percentage of men employed in mines where the established working day is 8 hours increased from 79 in 1917 to nearly 91 in 1918, compared with 60 in 1916. The change from 1917 to 1918 was brought about by the more general adoption of the 8-hour day in Alabama, Pennsylvania, Tennessee, Virginia, and West Virginia.

It should be remembered, however, that when the length of the working day is stated reference is made to the number of hours the

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mines are supposed to be in operation and not the number of hours the miners actually work. In both the anthracite and the bituminous fields practically all the coal is mined by contract at an agreed rate per ton or other basis of payment. The miner is an independent contractor and is not obliged to put in a certain number of hours at his working place. The figures in the following table really indicate the number of hours the men were given an opportunity to labor during a full working day and do not mean that all the employees worked 8, 9, or 10 hours, as the case may have been.

From 1903, after the settlement of the anthracite strike, until 1916 the established working day in the Pennsylvania anthracite region was 9 hours. Since 1916 the 8-hour day has prevailed in that region.

Length of working day in bituminous coal mines in the United States in 1917 and 1918.

State.	8 hours.		9 hours.		10 hours.		All others.
	Mines.	Men.	Mines.	Men.	Mines.	Men.	Men.
1917.							
Alabama	38	3,586	27	1,900	143	20,766	2,134
Arkansas	68	3,636	1	5	1	3	354
Colorado	130	12,238	.....	.....	.....	.....	1,993
Illinois	402	82,435	4	50	.....	.....	1,605
Indiana	181	24,294	2	42	.....	.....	2,192
Iowa	130	13,328	1	11	.....	.....	927
Kansas	120	10,144	.....	.....	.....	.....	536
Kentucky	217	16,738	84	5,488	69	3,833	8,867
Maryland	61	4,766	1	25	5	359	769
Michigan	19	2,375	.....	.....	.....	.....	31
Missouri	130	9,141	1	10	1	25	492
Montana	34	4,105	.....	.....	.....	.....	44
New Mexico	26	a 2,617	.....	.....	.....	.....	1,509
North Dakota	10	109	2	30	15	320	362
Ohio	489	43,423	7	82	9	481	1,523
Oklahoma	98	7,890	.....	.....	2	56	549
Oregon	5	70	.....	.....	.....	.....	34
Pennsylvania (bituminous)	1,293	124,824	230	27,293	79	6,135	15,716
Tennessee	51	2,630	59	5,748	8	1,539	504
Texas	13	2,213	16	930	12	946	286
Utah	20	3,417	1	6	.....	.....	62
Virginia	27	1,484	17	1,141	39	4,160	4,383
Washington	47	5,085	.....	.....	.....	.....	227
West Virginia	601	41,199	244	25,552	99	7,126	14,545
Wyoming	52	7,349	.....	.....	1	9	.....
	4,262	429,096	697	68,313	483	45,758	59,644
1918.							
Alabama	235	24,129	3	72	8	872	1,148
Arkansas	74	3,416	1	8	1	13	541
Colorado	169	13,741	1	99	1	2	641
Illinois	454	85,320	3	33	.....	.....	612
Indiana	255	28,612	1	15	.....	.....	1,740
Iowa	125	12,242	1	12	.....	.....	1,074
Kansas	141	9,672	.....	.....	.....	.....	993
Kentucky	376	26,601	93	5,271	55	4,363	3,107
Maryland	85	5,334	.....	.....	.....	.....	234
Michigan	21	2,526	.....	.....	.....	.....	32
Missouri	149	8,685	5	99	2	31	775
Montana	44	4,470	.....	.....	2	8	81
New Mexico	32	4,023	1	34	.....	.....	38
North Dakota	16	464	1	15	9	142	207
Ohio	635	46,184	9	242	15	645	1,379
Oklahoma	109	7,777	2	109	1	10	555
Oregon	1	30	.....	.....	.....	.....	10
Pennsylvania (bituminous)	1,698	151,586	146	7,439	52	4,198	11,083
Tennessee	109	8,380	5	422	2	849	1,043
Texas	16	2,074	15	855	6	577	430
Utah	26	4,111	1	5	.....	.....	44
Virginia	84	8,916	16	1,034	8	514	540
Washington	51	5,070	.....	.....	.....	.....	39
West Virginia	915	58,782	263	23,540	54	3,385	3,823
Wyoming	51	7,194	.....	.....	.....	.....	360
	5,871	529,339	567	39,304	216	15,609	30,538

a Includes 346 outside men with 9-hour working day.

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STRIKES.

The year 1918 presents a most notable record with respect to strikes and labor trouble in the coal-mining industry. The records of the Geological Survey covering the subject of time lost through strikes in coal mines extend back to 1899, and in no year have these records shown fewer strikes and less time lost on that account than in 1918. The reports for 1918 show 438,882 man-days lost in the bituminous mines because of strikes in 1918—60,105 men for an average of 7 days each. The nearest approach to that figure was in 1907, when 462,392 man-days were lost, but if the time lost is considered together with the total number of men employed or the total man-days worked in the two years, the absence of strikes in 1918 becomes all the more evident.

Labor, of course, laid aside personal contentions during the war. The Government, through the Fuel Administrator, was a powerful influence to anticipate and adjust grievances. The record for 1918 is one of which labor can justly be proud.

No strikes were reported in 1918 from New Mexico and Oregon, where strikes occurred in 1917. A small loss of time on that account was reported from Georgia in 1918, but none in 1917. Among the other States in which strikes were reported in 1917, some decrease in time lost through that cause was recorded in 1918 for all except Michigan, Texas, Virginia, and Washington.

Labor strikes in the coal mines of the United States in 1917 and 1918.

State.	1917			1918		
	Number of men on strike.	Total days lost.	Average number of days lost per man.	Number of men on strike.	Total days lost.	Average number of days lost per man.
Alabama	1,835	10,220	6	1,952	3,259	2
Arkansas	2,417	27,315	11	1,207	4,292	4
Colorado	1,664	7,292	4	464	2,318	5
Georgia				230	1,610	7
Illinois	38,781	464,511	12	10,251	74,850	7
Indiana	11,914	74,695	6	8,083	51,015	6
Iowa	3,275	18,407	6	997	4,774	5
Kansas	7,312	128,514	18	4,675	25,047	5
Kentucky	9,348	425,725	46	1,226	15,318	12
Maryland	1,523	24,605	16	2,517	5,402	2
Michigan	163	1,964	12	1,367	18,194	13
Missouri	2,175	31,767	15	1,191	5,900	5
Montana	1,063	23,680	22	218	218	1
New Mexico	85	775	9			
North Dakota	82	811	10	22	166	8
Ohio	7,710	56,875	7	4,993	44,837	9
Oklahoma	1,668	37,301	22	630	12,294	20
Oregon	25	25	1			
Pennsylvania (bituminous)	23,655	544,322	23	12,852	112,929	9
Tennessee	4,448	192,730	43	835	2,454	3
Texas	75	260	3	55	550	10
Utah	212	848	4	30	30	1
Virginia	232	2,283	10	523	10,241	20
Washington	192	840	4	75	1,275	17
West Virginia	6,166	111,479	18	5,712	42,009	7
Total bituminous	126,020	2,187,244	17	60,105	438,882	7
Pennsylvania anthracite	34,220	161,155	5	19,290	69,644	4

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Summary of labor strikes in the coal mines of the United States, 1899–1918.

Year.	Number of men on strike.	Total working days lost.	Average number of days lost per man.
1899	45,981	2,124,154	46
1900	131,973	4,878,102	37
1901	20,593	733,802	35
1902	200,452	16,672,217	83
1903	47,481	1,341,031	28
1904	77,661	3,382,830	44
1905	37,542	796,735	21
1906	372,343	19,201,348	51.5
1907 a	32,540	462,392	14
1908 a	145,145	5,449,938	38
1909 a	24,763	723,634	29
1910	218,493	19,250,524	88
1911	41,413	983,737	24
1912	311,056	12,527,305	40
1913	135,395	3,049,412	22.5
1914	161,720	11,013,667	68
1915	67,190	2,467,431	37
1916	170,633	3,344,586	20
1917	160,240	2,348,399	15
1918	79,395	508,526	6

a Bituminous mines only.

PRODUCTION CLASSIFIED BY MINING METHODS.

The term "mining method" as used here refers to the manner in which the coal is broken down in the mine and not to the system of mining, as by room and pillar or long wall. In the mine the coal is either blasted from a solid face—shot from the solid—as in hard-rock mining, or is shot loose or otherwise broken down after a preliminary cut into the coal has been made. This cut may be made by hand or by machine. Underground methods are therefore classified as shooting from the solid, mining by hand, and mining by machine. An increasing quantity of coal is being recovered each year by stripping the cover from the bed in open pits by steam shovels. The bed thus exposed is for the most part shattered by powder and the coal is shoveled into cars by hand, although in places it is picked up directly by small steam shovels.

Opposition to shooting from the solid has arisen because it is injurious to the mining property in that the heavy charges of powder weaken the roof and pillars, thus increasing the liability to falls of roof and coal, the most prolific cause of fatal accidents to coal miners. Another objection to this method is that the heavy charges of powder required to blow down the coal where it has not been previously undercut or sheared result in the production of a much higher proportion of fine coal and render the lump coal so friable that it disintegrates in handling and in transportation. With the growing use of mechanical stokers and of powdered coal the latter objection is losing much of its force, but the danger has been in no wise diminished, and the method is forbidden by law in some of the coal-mining States.

It is interesting to note that in 1918, the year of maximum production, the percentage of product obtained by the use of machines was maintained and even slightly exceeded that in 1917. In 1918 the percentage of machine-mined product was 55.9, compared with 55.5 in 1917. Several of the banner States in the use of machines, however, recorded decreases—particularly Kentucky, from 83.6

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per cent in 1917 to 78.5 in 1918; Michigan, from 87.3 to 86.8 per cent; and Ohio, from 87.9 to 84.8 per cent.

The unusually large portion of the total production—more than 8,000,000 tons, or 1.4 per cent—for which the method of mining was not reported in 1918, came largely from small operations, mainly wagon mines, and was probably for the most part shot from the solid. The quantity of bituminous coal mined from steam-shovel pits in 1918 was 8,288,245 tons, or 1.4 per cent of the total output, compared with 5,789,977 tons, or 1.1 per cent of the output in 1917. Bituminous coal was mined from steam-shovel pits in 15 States in 1918, compared with 13 States in 1917, Iowa and Arkansas having been added to the list in 1918.

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Bituminous coal mined by different methods in 1917.

State.	Mined by hand.		Shot from the solid.		Mined by machines.		From steam-shovel pits.		Not reported.		Total production (net tons).
	Quantity (net tons).	Percentage.	Quantity (net tons).	Percentage.	Quantity (net tons).	Percentage.	Quantity (net tons).	Percentage.	Quantity (net tons).	Percentage.	
Alabama	5,340,112	26.6	8,419,146	42.0	6,062,744	30.1	231,217	1.2	14,855	0.1	20,068,074
Arkansas	153,393	7.2	1,816,941	84.8	154,615	7.2	.....	.....	18,630	.8	2,143,579
Colorado	7,367,335	59.0	946,555	7.6	4,077,520	32.7	.....	.....	91,926	.7	12,483,336
Georgia	1,625	1.4	117,403	98.6	.....	.....	.....	.....	.....	.....	119,028
Illinois	8,498,917	9.9	28,257,063	32.8	48,576,462	56.3	542,891	.6	324,124	.4	86,199,387
Indiana	2,149,258	8.1	8,629,572	32.5	14,344,845	54.1	1,273,253	4.8	142,401	.5	26,539,329
Iowa	1,956,825	21.8	5,905,912	65.9	1,022,101	11.4	.....	.....	80,992	.9	8,965,830
Kansas	1,515,230	21.1	4,798,921	66.8	34,823	.5	806,985	11.2	29,016	.4	7,184,975
Kentucky	1,456,657	5.2	3,021,667	10.8	23,221,880	83.6	665	.....	107,102	.4	27,807,971
Maryland	3,506,888	73.9	880,665	18.6	290,116	6.1	20,840	.4	47,415	1.0	4,745,924
Michigan	47,180	3.4	127,134	9.2	1,199,263	87.3	.....	.....	1,228	.1	1,374,805
Missouri	1,102,961	19.4	2,080,218	36.7	1,127,843	19.9	1,139,000	20.1	220,527	3.9	5,670,549
Montana	1,496,419	35.4	605,224	14.3	2,070,075	49.0	.....	.....	54,971	1.3	4,226,689
New Mexico	2,726,844	68.2	208,526	5.2	1,052,684	26.3	.....	.....	12,473	.3	4,000,527
North Dakota	49,209	6.2	339,240	42.9	300,417	38.0	7,351	.9	94,331	12.0	790,548
Ohio	1,636,066	4.0	1,360,217	3.3	35,828,497	87.9	1,249,181	3.1	674,773	1.7	40,748,734
Oklahoma	21,353	.5	2,587,942	59.0	1,605,117	36.6	155,740	3.5	16,692	.4	4,386,844
Pennsylvania (bituminous)	63,498,114	36.8	12,441,129	7.2	95,423,140	55.4	349,944	.2	735,815	.4	172,448,142
Tennessee	2,026,570	32.7	2,753,808	44.5	1,399,825	22.6	.....	.....	14,018	.2	6,194,221
Texas	1,875,510	79.6	477,617	20.3	2,688	.1	.....	.....	.....	.....	2,355,815
Utah	1,553,806	37.7	306,255	7.4	2,259,697	54.8	.....	.....	5,472	.1	4,125,230
Virginia	370,685	3.7	3,261,669	32.3	6,440,561	63.9	.....	.....	14,176	.1	10,087,091
Washington	2,395,479	59.7	1,382,567	34.5	231,856	5.8	.....	.....	.....	.....	4,009,902
West Virginia	28,935,091	33.5	1,259,902	1.5	56,075,888	64.8	6,000	.....	164,786	.2	86,441,667
Wyoming	1,374,626	16.0	3,596,403	42.0	3,593,470	41.9	7,000	.1	4,120	.....	8,575,619
Other States	28,414	29.4	60,291	62.3	.....	.....	.....	.....	8,042	8.3	96,747
Total bituminous	141,084,567	25.6	95,642,007	17.3	306,396,127	55.5	5,789,977	1.1	2,877,885	.5	551,790,563
Pennsylvania anthracite	(a)	.....	(a)	.....	1,955,223	2.0	2,301,588	2.3	.....	.....	99,611,811

a This information not requested by the United States Geological Survey.

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Bituminous coal mined by different methods in 1918.

State.	Mined by hand.		Shot from the solid.		Mined by machines.		From steam-shovel pits.		Not reported.		Total production (net tons).
	Quantity (net tons).	Percentage.	Quantity (net tons).	Percentage.	Quantity (net tons).	Percentage.	Quantity (net tons).	Percentage.	Quantity (net tons).	Percentage.	
Alabama	4,240,978	22.1	8,496,732	44.3	5,951,547	31.0	231,078	1.2	264,627	1.4	19,184,962
Arkansas	140,654	6.3	1,727,298	77.6	242,984	10.9	7,200	.3	109,238	4.9	2,227,369
Colorado	6,705,256	54.0	906,498	7.3	4,574,017	36.9	.....	.....	221,800	1.8	12,407,571
Georgia	1,720	2.6	64,996	97.4	.....	.....	.....	.....	.....	.....	66,716
Illinois	8,486,806	9.5	29,523,059	33.1	50,566,911	56.6	512,863	.6	201,466	.2	89,291,105
Indiana	3,537,242	11.5	10,530,421	34.3	14,997,532	49.0	1,391,336	4.5	222,103	.7	30,678,634
Iowa	2,283,233	27.9	4,794,809	58.5	876,754	10.7	4,100	.1	233,299	2.8	8,192,195
Kansas	472,238	6.2	5,843,916	77.4	56,314	.7	917,345	12.1	272,134	3.6	7,561,947
Kentucky	1,358,909	4.3	4,781,483	15.1	24,808,171	78.5	12,000	.....	652,054	2.1	31,612,617
Maryland	3,266,199	72.6	785,201	17.5	301,965	6.7	14,651	.3	129,281	2.9	4,497,297
Michigan	12,782	.9	141,495	9.7	1,272,285	86.8	.....	.....	38,256	2.6	1,464,818
Missouri	932,448	16.5	2,050,056	36.2	1,244,682	22.0	1,201,583	21.1	238,961	4.2	5,667,730
Montana	959,322	21.2	1,278,452	28.2	2,268,318	50.0	.....	.....	26,413	.6	4,532,505
New Mexico	2,400,607	59.8	363,799	9.0	1,236,709	30.7	.....	.....	22,124	.5	4,023,239
North Dakota	34,059	4.7	253,365	35.2	344,482	47.9	3,434	.5	84,393	11.7	719,733
Ohio	1,450,940	3.2	1,700,960	3.7	38,841,452	84.8	2,705,785	5.9	1,113,806	2.4	45,812,943
Oklahoma	189,808	3.9	2,516,876	52.3	1,899,487	39.5	160,064	3.3	47,212	1.0	4,813,447
Pennsylvania (bituminous)	63,719,407	35.7	12,308,963	6.9	98,334,139	55.0	1,031,578	.6	3,156,654	1.8	178,550,741
Tennessee	1,829,414	26.8	3,286,551	48.1	1,549,945	22.7	.....	.....	165,138	2.4	6,831,048
Texas	1,718,336	76.0	486,799	21.5	2,000	.1	.....	.....	54,000	2.4	2,261,135
Utah	1,885,318	36.7	473,227	9.2	2,767,084	53.9	.....	.....	11,196	.2	5,136,825
Virginia	1,535,032	14.9	2,027,310	19.7	6,394,276	62.2	.....	.....	333,190	3.2	10,289,808
Washington	2,360,044	57.8	1,473,058	36.1	249,110	6.1	.....	.....	.....	.....	4,082,212
West Virginia	26,069,413	29.0	2,478,421	2.8	60,688,232	67.5	26,595	.....	673,178	.7	89,935,839
Wyoming	2,040,907	21.6	2,802,922	29.7	4,462,737	47.3	68,633	.7	63,489	.7	9,438,688
Other States	24,335	23.2	72,319	69.1	.....	.....	.....	.....	8,042	7.7	104,696
Total bituminous	137,655,407	23.8	101,168,981	17.5	323,931,133	55.9	8,288,245	1.4	8,342,054	1.4	579,385,820
Pennsylvania anthracite	(a)	.....	(a)	.....	1,857,514	1.9	2,360,183	2.4	.....	.....	98,826,084

a This information not requested by the United States Geological Survey.

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PRODUCTION BY MACHINES.

The production of bituminous coal by machines in 1918 was 323,931,000 tons, or 55.9 per cent of the total output, compared with 306,396,000 tons, or 55.5 per cent, in 1917. The number of machines in use increased from 17,235 in 1917 to 18,463 in 1918. The number of machines in use increased in every State except Tennessee, where the number decreased from 209 in 1917 to 200 in 1918, and in North Dakota and Texas, where there was no change. The number of mining machines in use in 1918 was the highest recorded; the previous high record having been reached in 1917. The average output per machine in 1918 was 17,545 tons which has been exceeded only in 1917—17,777 tons per machine.

The quantity of Pennsylvania anthracite mined by machines increased from 1,955,223 net tons in 1917 to 1,857,514 tons in 1918.

Bituminous coal mined by machines in the United States, 1917 and 1918.

State.	Machines in use.		Quantity mined by machines (net tons).		Percentage of total product mined by machines.	
	1917	1918	1917	1918	1917	1918
Alabama	332	403	6,062,744	5,951,547	30.1	31.0
Arkansas	18	24	154,615	242,984	7.2	10.9
Colorado	328	352	4,077,530	4,574,017	32.7	36.9
Illinois	2,049	2,152	48,576,462	50,566,911	56.3	56.6
Indiana	768	904	14,344,845	14,997,532	54.1	49.0
Iowa	71	72	1,022,101	876,754	11.4	10.7
Kansas	9	16	34,823	56,314	.5	.7
Kentucky	1,514	1,634	23,221,880	24,808,171	83.6	78.5
Maryland	20	25	290,116	301,965	6.1	6.7
Michigan	99	111	1,199,263	1,272,285	87.3	86.8
Missouri	100	104	1,127,843	1,244,682	19.9	22.0
Montana	115	116	2,070,075	2,268,318	49.0	50.0
New Mexico	75	97	1,052,684	1,236,709	26.3	30.7
North Dakota	16	16	300,417	344,482	38.0	47.9
Ohio	1,784	1,987	35,828,497	38,841,452	87.9	84.8
Oklahoma	145	178	1,605,117	1,899,487	36.6	39.5
Pennsylvania	6,004	6,207	95,423,140	98,334,139	55.4	55.0
Tennessee	209	200	1,399,825	1,549,945	22.6	22.7
Texas	1	1	2,688	2,000	.1	.1
Utah	105	141	2,259,697	2,767,084	54.8	53.9
Virginia	226	231	6,440,561	6,394,276	63.9	62.2
Washington	32	48	231,856	249,110	5.8	6.1
West Virginia	3,054	3,281	56,075,888	60,688,232	64.8	67.5
Wyoming	161	163	3,593,470	4,462,737	41.9	47.3
	17,235	18,463	306,396,127	323,931,133	[a]55.5	[a]55.9

[a] Average.

Bituminous coal mined by machines in the United States, 1891–1918.

Year.	Machines in use.	Quantity mined by machines (net tons).	Average production for each machine (net tons).	Year.	Machines in use.	Quantity mined by machines (net tons).	Average production for each machine (net tons).
1891	545	6,211,732	11,398	1907	11,144	138,547,823	12,432
1896	1,446	16,424,032	11,373	1908	11,569	123,183,334	10,648
1897	1,956	22,649,220	11,579	1909	13,049	142,496,378	10,920
1898	2,822	32,413,144	12,362	1910	13,254	174,013,293	13,127
1899	3,125	43,963,033	14,068	1911	13,829	178,158,236	12,884
1900	3,907	52,784,523	13,510	1912	15,298	210,538,922	13,763
1901	4,341	57,843,335	13,325	1913	16,379	242,421,713	14,801
1902	5,418	69,611,582	12,848	1914	16,507	218,399,287	13,231
1903	6,658	77,974,894	11,712	1915	15,692	243,237,551	15,501
1904	7,663	78,606,997	10,258	1916	16,198	283,691,475	17,514
1905	9,184	103,396,452	11,258	1917	17,235	306,396,127	17,777
1906	10,212	118,847,527	11,638	1918	18,463	323,931,133	17,545

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Anthracite (Pennsylvania) mined by machines, 1913–1918.

Year.	Quantity (gross tons).	Year.	Quantity (gross tons).
1913	496,229	1916	1,642,416
1914	818,389	1917	1,745,735
1915	1,167,639	1918	1,658,495

PRODUCTION FROM STEAM-SHOVEL PITS.

The steam-shovel branch of the bituminous-coal industry received a marked impetus in 1918 because of the tremendous demand for coal. The number of shovels (the figures here given include electric as well as steam shovels) in use increased from 111 in 8 States in 1916 and 182 in 13 States in 1917 to 276 in 15 States in 1918. The quantity of bituminous coal and lignite recovered from shovel pits rose from 3,933,000 tons in 1916 and 5,790,000 tons in 1917 to 8,288,000 tons in 1918.

The number of steam shovels reported in use in the Pennsylvania anthracite regions increased from 76 in 1917 to 82 in 1918; in both years, however, this was less than the number (105) in 1916.

Coal recovered from steam-shovel strip pits in 1917 and 1918.

State.	1917		1918	
	Number of shovels.	Quantity of coal mined (net tons).	Number of shovels.	Quantity of coal mined (net tons).
Alabama	9	231,217	13	231,078
Arkansas			1	7,200
Illinois	11	542,801	14	512,863
Indiana	26	1,273,253	45	1,391,336
Iowa			1	4,100
Kansas	26	806,985	25	917,345
Kentucky	1	665	2	12,000
Maryland	4	20,340	2	14,651
Missouri	30	1,139,000	30	1,201,583
North Dakota	1	7,351	1	3,434
Ohio	36	1,249,181	74	2,705,785
Oklahoma	5	155,740	7	160,064
Pennsylvania (bituminous)	31	349,944	51	1,031,578
West Virginia	1	6,000	7	26,595
Wyoming	1	7,000	3	68,633
Total bituminous	182	5,789,977	276	8,288,245
Pennsylvania anthracite	76	2,301,588	82	2,360,183
Grand total	258	8,091,565	358	10,648,428

COAL-WASHING OPERATIONS.

The quantity of coal washed in 1918 was 25,119,548 tons, from which 22,017,293 tons of cleaned coal was obtained, and more than 3,000,000 tons of refuse thrown out. Compared with both 1917 (25,483,696 tons of cleaned coal) and 1916 (22,922,218 tons of cleaned coal), the record for 1918 represents a decrease. The largest decreases were in Alabama, nearly 2,000,000 tons, and in Pennsylvania, about 1,600,000 tons.

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Bituminous coal washed at the mines in 1917 and 1918.

State.	Coal washed (net tons).	Cleaned coal (net tons).	Refuse (net tons).	Percentage of cleaned coal to total State output.
1917.				
Alabama	12,714,868	11,408,051	1,306,817	56.8
Colorado	322,277	267,096	55,181	2.1
Georgia	91,076	73,793	17,283	62.0
Illinois	5,159,079	4,651,154	507,925	5.4
Indiana	52,442	48,065	4,377	.2
Kentucky	237,975	211,689	26,286	.8
Maryland	35,712	34,693	1,019	.7
Michigan	204,998	174,642	30,356	12.7
Missouri	45,759	37,617	8,142	.7
Montana	263,798	243,475	20,323	5.8
New Mexico	531,881	478,834	53,047	12.0
Ohio	74,689	66,785	7,904	.2
Oregon	10,612	9,551	1,061	33.7
Pennsylvania	3,786,135	3,400,075	386,060	2.0
Tennessee	697,953	630,621	67,332	10.2
Texas	34,282	23,817	10,465	1.0
Virginia	398,457	361,489	36,968	3.6
Washington	1,853,818	1,475,529	378,289	36.8
West Virginia	2,071,326	1,886,720	184,606	2.2
	28,587,137	25,483,696	3,103,441	4.9
1918.				
Alabama	10,895,953	9,449,901	1,446,052	49.3
Colorado	1,331,399	1,139,876	191,523	9.2
Georgia	45,574	37,853	7,721	56.7
Illinois	5,008,367	4,595,229	413,138	5.1
Indiana	61,082	56,880	4,202	.2
Kentucky	112,985	103,109	9,876	.3
Michigan	187,517	166,998	20,519	11.4
Missouri	23,280	20,826	2,454	.4
Montana	314,951	262,203	52,748	5.8
Ohio	4,100	3,980	120	.....
Oregon	4,272	3,822	450	28.7
Pennsylvania	2,001,663	1,817,470	184,193	1.0
Tennessee	606,972	546,972	60,000	8.0
Texas	28,066	19,998	8,068	.9
Virginia	214,819	194,174	20,645	1.9
Washington	1,954,124	1,481,831	472,293	36.3
West Virginia	2,324,424	2,116,171	208,253	2.4
	25,119,548	22,017,293	3,102,255	4.1

VALUE.

The value of coal given in this report is the realization value at the mine f. o. b. cars, and the average value per ton is the average realization price obtained by dividing the total value by the number of tons sold or produced. The coal used at the mine, the coal coked by the producing company, and the coal used in some other industry by the company operating the mine—an appreciable proportion of the whole—is never sold, and the value placed upon it is either an estimate or the figure at which it is carried on the books, either of which is supposedly based on what the coal would have brought if sold or what other fuel for the respective purpose would have cost if its purchase had been necessary. In other words, the values given represent returns to the operators for coal sold, plus estimated exchange value of that not sold. These figures do not necessarily show prices or even an average of the prices of coal at the mine.[1]

[1] For a study of prices and of Government control of prices, see the report on prices of coal and coke in Mineral Resources of the United States, 1918.

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The average price realized for bituminous coal in 1918 was the highest ever recorded. The prices received for coal in 1918 were largely determined by the maxima established by the Fuel Administration, only coal under contract entered into prior to August 21, 1917, not being affected by these Government prices. It has been estimated that the average price realized in 1918 if all the coal had been sold at the prevailing Government price would have been $2.56 a ton compared with the average actually received, $2.58.

The average price realized for anthracite in 1918—$3.40 per net ton—was 55 cents greater than in 1917. The increase in wages paid to miners in 1918 over those paid in 1917 and previous years was largely responsible for the increase in prices, because it increased the cost of production.

Average value per net ton of coal at the mines since 1908.

State.	1908	1909	1910	1911	1912	1913	1914	1915	1916	1917	1918	Increase or decrease in 1918.
Alabama	$1.26	$1.19	$1.26	$1.27	$1.29	$1.31	$1.34	$1.28	$1.37	$2.27	$2.85	+$0.58
Alaska	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	4.00	4.92	5.45	+ .53
Arkansas	1.68	1.48	1.56	1.61	1.71	1.76	1.72	1.79	1.92	2.56	3.67	+ 1.11
California	b 3.19	b 2.21	b 2.74	b 2.00	b 2.33	b 3.54	c 2.85	c 2.54	c 2.12	c 2.30	c 2.70	+ .40
Colorado	1.41	1.33	1.42	1.45	1.49	1.52	1.66	1.58	1.62	2.22	2.69	+ .47
Georgia	1.38	1.41	1.46	d 1.49	d 1.49	1.41	e 1.44	1.72	1.79	2.53	3.59	+ 1.06
Idaho	4.02	4.27	3.92	f 2.68	f 3.14	2.43	(c)	(c)	(c)	(c)	(c)	(c)
Illinois	1.05	1.05	1.14	1.11	1.17	1.14	1.12	1.10	1.25	1.88	2.32	+ .44
Indiana	1.06	1.02	1.13	1.08	1.14	1.11	1.10	1.10	1.27	1.99	2.29	+ .30
Iowa	1.63	1.65	1.75	1.73	1.80	1.79	1.79	1.78	1.86	2.35	3.02	+ .67
Kansas	1.49	1.44	1.61	1.53	1.62	1.67	1.64	1.66	1.78	2.31	2.91	+ .60
Kentucky	1.01	.94	.99	.99	1.02	1.05	1.02	1.01	1.19	2.17	2.55	+ .38
Maryland	1.17	1.11	1.12	1.11	1.18	1.24	1.27	1.28	1.56	2.46	2.77	+ .31
Michigan	1.81	1.79	1.91	1.78	1.99	1.99	1.99	2.05	2.25	3.22	3.83	+ .61
Missouri	1.64	1.65	1.79	1.72	1.76	1.73	1.73	1.73	1.91	2.43	3.02	+ .59
Montana	1.96	1.97	1.82	1.79	1.82	1.74	1.75	1.62	1.73	2.11	2.53	+ .42
New Mexico	1.37	1.29	1.39	1.44	1.42	1.46	1.61	1.44	1.47	1.86	2.68	+ .82
North Carolina											4.75	
North Dakota	1.63	1.56	1.49	1.43	1.53	1.52	1.52	1.45	1.49	1.80	2.45	+ .65
Ohio	1.06	.99	1.05	1.03	1.07	1.10	1.13	1.08	1.33	2.48	2.58	+ .10
Oklahoma	2.03	2.00	2.22	2.05	2.14	2.05	2.06	2.01	2.09	2.81	3.64	+ .83
Oregon	2.74	2.69	3.48	2.32	2.60	2.53	2.78	2.84	2.68	3.38	2.81	− .57
Pennsylvania (bituminous)	1.01	.94	1.02	1.01	1.05	1.11	1.07	1.06	1.30	2.44	2.59	+ .15
South Dakota						1.96	1.73	1.55	2.03	2.90	2.80	− .10
Tennessee	1.15	1.09	1.11	1.12	1.14	1.14	1.14	1.13	1.23	2.19	2.83	+ .64
Texas	1.80	1.72	1.67	1.66	1.67	1.77	1.69	1.65	1.56	1.77	2.63	+ .86
Utah	1.69	1.66	1.68	1.69	1.67	1.65	1.59	1.58	1.62	2.07	2.71	+ .64
Virginia	.91	.89	.90	.91	.96	1.01	1.01	.98	1.06	2.00	2.51	+ .51
Washington	2.21	2.54	2.50	2.29	2.39	2.38	2.20	2.17	2.27	2.68	3.46	+ .78
West Virginia	.95	.86	.92	.90	.94	1.01	.99	.97	1.18	2.32	2.56	+ .24
Wyoming	1.62	1.55	1.55	1.56	1.58	1.56	1.55	1.46	1.55	1.93	2.39	+ .46
Total bituminous	1.12	1.07	1.12	1.11	1.15	1.18	1.17	1.13	1.32	2.26	2.58	+ .32
Pennsylvania anthracite	1.90	1.84	1.90	1.94	2.11	2.13	2.07	2.07	2.30	2.85	3.40	+ .55

a Included with California.
b Includes Alaska.
c California includes Alaska, Idaho, and Nevada in 1914 and 1915; Idaho in 1916, 1917, and 1918.
d Includes North Carolina.
e Average for total output, including refuse from washery. The average, excluding refuse, was $1.71.
f Includes Nevada.

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Average value per net ton of coal at the mines in the United States for 39 years.

Year.	Anthracite.	Bituminous.	Year.	Anthracite.	Bituminous.
1880	$1.47	$1.25	1900	$1.49	$1.04
1881	2.01	1.12	1901	1.67	1.05
1882	2.01	1.12	1902	1.84	1.12
1883	2.01	1.07	1903	2.04	1.24
1884	1.79	.94	1904	1.90	1.10
1885	2.00	1.13	1905	1.83	1.06
1886	1.95	1.05	1906	1.85	1.11
1887	2.01	1.11	1907	1.91	1.14
1888	1.91	1.00	1908	1.90	1.12
1889	1.44	.99	1909	1.84	1.07
1890	1.43	.99	1910	1.90	1.12
1891	1.46	.99	1911	1.94	1.11
1892	1.57	.99	1912	2.11	1.15
1893	1.59	.96	1913	2.13	1.18
1894	1.51	.91	1914	2.07	1.17
1895	1.41	.86	1915	2.07	1.13
1896	1.50	.83	1916	2.30	1.32
1897	1.51	.81	1917	2.85	2.26
1898	1.41	.80	1918	3.40	2.58
1899	1.46	.87			

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Value of coal produced in the United States in 1917.

State.	Loaded at mines for shipment.	Average value per ton.	Sold to local trade and used by employees.	Average value per ton.	Used at mines for steam and heat.	Average value per ton.	Made into coke at mines.	Average value per ton.	Total value.	Average value per ton.
Alabama	$33,391,495	$2.19	$1,021,115	$2.01	$1,331,855	$2.08	$9,872,527	$2.71	$45,616,992	$2.27
Alaska			265,317	4.92					265,317	4.92
Arkansas	5,148,786	2.56	180,844	3.06	163,147	2.17			5,492,777	2.56
California and Idaho	6,196	2.21	8,235	2.43	360	1.50			14,791	2.30
Colorado	22,665,626	2.32	1,066,267	2.37	477,579	2.55	3,459,657	1.77	27,669,129	2.22
Georgia	107,469	2.84	2,074	1.62	11,490	1.60	180,358	2.48	301,391	2.53
Illinois	150,747,394	1.88	7,706,905	2.18	3,827,523	1.61			162,281,822	1.88
Indiana	49,922,167	2.00	1,842,057	2.03	1,175,882	1.83			52,940,106	1.99
Iowa	18,523,946	2.33	2,178,536	2.78	393,626	1.74			21,096,408	2.35
Kansas	15,807,949	2.31	466,326	2.89	345,002	1.86			16,618,277	2.31
Kentucky	56,436,837	2.20	1,667,589	1.87	1,063,544	1.69	1,109,683	1.85	60,297,653	2.17
Maryland	11,315,888	2.47	210,943	2.02	141,021	2.39			11,667,852	2.46
Michigan	3,940,104	3.17	342,616	4.18	143,594	2.99			4,426,314	3.22
Missouri	11,896,680	2.41	1,534,744	2.65	334,460	2.20			13,755,864	2.43
Montana	8,225,437	2.12	460,046	2.61	233,653	1.39			8,919,136	2.11
New Mexico	5,920,518	2.02	108,192	2.31	65,975	1.81	1,365,481	1.38	7,455,166	1.86
North Dakota	1,005,897	1.80	373,296	1.90	46,557	1.37			1,425,750	1.80
Ohio	93,890,397	2.51	5,443,716	2.15	1,561,835	2.08	1,200	1.90	100,897,148	2.48
Oklahoma	11,754,785	2.83	139,520	3.07	441,108	2.33			12,335,413	2.81
Oregon	54,068	3.98	35,491	3.91	5,504	1.00			95,063	3.38
Pennsylvania (bituminous)	332,497,267	2.58	11,619,410	2.20	7,266,631	2.08	69,885,500	2.01	421,268,808	2.44
South Dakota	2,414	3.73	20,932	2.83					23,346	2.90
Tennessee	11,874,273	2.30	265,899	1.96	313,901	1.91	1,139,025	1.57	13,592,998	2.19
Texas	4,103,221	1.79	26,245	1.79	49,142	1.00			4,177,608	1.77
Utah	[a] 8,304,971	2.10	150,387	1.95	76,024	.98	(a)	(a)	8,531,382	2.07
Virginia	16,333,972	2.11	350,006	2.02	257,661	1.77	3,184,074	1.56	20,125,713	2.00
Washington	9,671,252	2.68	176,970	2.46	317,610	1.91	562,530	3.57	10,727,362	2.68
West Virginia	135,720,321	2.38	5,054,200	2.03	2,174,139	1.82	7,691,648	1.62	200,639,368	2.32
Wyoming	16,033,589	1.96	286,449	2.28	273,245	1.01			16,593,283	1.93
Total bituminous	1,085,312,499	2.31	42,996,687	2.20	22,511,968	1.86	98,451,683	1.98	1,249,272,837	2.26
Pennsylvania anthracite	269,193,801	3.10	6,070,907	2.55	8,386,015	.80			283,650,723	2.85
Grand total	1,354,506,300	2.43	49,067,594	2.24	30,897,983	1.37	98,451,683	1.98	1,532,923,560	2.35

[a] Value of coal made into coke at the mines included in loaded at mines for shipment.

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Value of coal produced in the United States in 1918.

State.	Loaded at mines for shipment.	Average value per ton.	Sold to local trade and used by employees.	Average value per ton.	Used at mines for steam and heat.	Average value per ton.	Made into coke at mines.	Average value per ton.	Total value.	Average value per ton.
Alabama	$44,138,422	$2.75	$710,320	$2.34	$1,864,872	$3.14	$8,038,715	$3.61	$54,752,329	$2.85
Alaska	380,173	5.65	21,659	3.39	10,018	5.12			411,850	5.45
Arkansas	7,781,718	3.68	159,682	3.85	230,976	3.12			8,172,376	3.67
California and Idaho	15,300	2.64	1,950	3.25					17,250	2.70
Colorado	28,588,527	2.70	1,158,498	2.66	696,057	2.24	2,961,661	2.74	33,404,743	2.69
Georgia	87,548	4.03	1,768	1.99	18,101	2.90	131,960	3.49	239,377	3.59
Illinois	192,778,821	2.32	9,402,946	2.58	4,678,524	1.96			206,860,291	2.32
Indiana	66,575,299	2.30	2,179,094	2.31	1,630,208	2.10			70,384,601	2.29
Iowa	22,207,297	3.00	2,047,815	3.40	448,125	2.35			24,703,237	3.02
Kansas	20,946,080	2.91	558,277	3.22	523,785	2.62			22,028,142	2.91
Kentucky	75,283,852	2.56	2,490,191	2.36	1,361,176	2.01	1,541,623	2.89	80,666,842	2.55
Maryland	12,050,898	2.77	261,559	2.66	153,732	2.76			12,466,189	2.77
Michigan	4,899,343	3.83	441,610	4.46	274,144	3.22			5,615,097	3.83
Missouri	15,366,671	3.00	1,326,210	3.44	433,617	2.67			17,126,498	3.02
Montana	10,654,343	2.55	513,370	2.87	277,162	1.58			11,444,875	2.53
New Mexico	8,681,568	3.06	96,910	2.48	114,513	2.92	1,894,091	1.71	10,787,082	2.68
North Carolina	2,214	4.75	199	4.74	4,332	4.75			6,745	4.75
North Dakota	1,218,365	2.32	387,347	2.23	23,956	1.20			1,629,668	2.26
Ohio	111,064,015	2.59	4,916,880	2.44	2,114,643	2.33			118,095,518	2.58
Oklahoma	16,636,685	3.64	149,455	3.97	722,744	3.48			17,508,884	3.64
Oregon	15,420	3.75	14,767	3.74	7,267	1.38			37,454	2.81
Pennsylvania (bituminous)	371,909,415	2.70	12,338,473	2.48	8,448,368	2.34	70,463,480	2.17	463,159,736	2.59
South Dakota	2,596	4.06	19,634	2.69					22,230	2.80
Tennessee	16,971,180	2.87	383,470	2.59	477,443	2.62	1,473,110	2.47	19,305,203	2.83
Texas	5,849,045	2.65	30,011	2.53	58,941	1.31			5,937,997	2.63
Utah	13,605,292	3.21	149,908	2.31	181,897	1.92	(a)	(a)	13,937,097	2.71
Virginia	20,828,751	2.54	852,072	2.17	226,058	2.10	3,959,014	2.47	25,865,895	2.51
Washington	12,496,815	3.41	264,317	3.56	519,698	2.68	853,039	5.52	14,132,869	3.46
West Virginia	211,148,254	2.59	6,327,322	2.40	2,667,767	2.30	10,365,503	2.27	230,508,846	2.56
Wyoming	21,867,615	2.41	295,696	2.26	417,708	1.65			22,581,019	2.39
Total bituminous	1,314,050,522	2.61	47,491,390	2.54	28,585,832	2.28	101,682,196	2.25	1,491,809,940	2.58
Pennsylvania anthracite	317,522,181	3.70	7,746,256	2.90	11,211,910	1.10			336,480,347	3.40
Grand total	1,631,572,703	2.77	55,237,646	2.59	39,797,742	1.75	101,682,196	2.25	1,828,290,287	2.70

[a] Value of coal made into coke at the mines included in loaded at mines for shipment.

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PRODUCTION OF COAL, BY STATES.

ALABAMA.

The production of coal in Alabama in 1918 was 19,184,962 tons, valued at $54,752,329, a decrease, compared with 1917, of 883,112 tons, or 4.4 per cent, in quantity but a gain of $9,135,337, or 20 per cent, in value. No lack of demand interfered with production of coal in Alabama in 1918 nor was there at any time a serious lack of transportation for the coal from mine to market. The greater part of the coal produced in the State is consumed within a comparatively short distance from the mines and car shortage does not affect this field as in other parts of the country. The decrease in 1918 is to be attributed to an actual shortage of mine labor. There were employed in the production of coal in Alabama in 1918, 26,221 men, compared

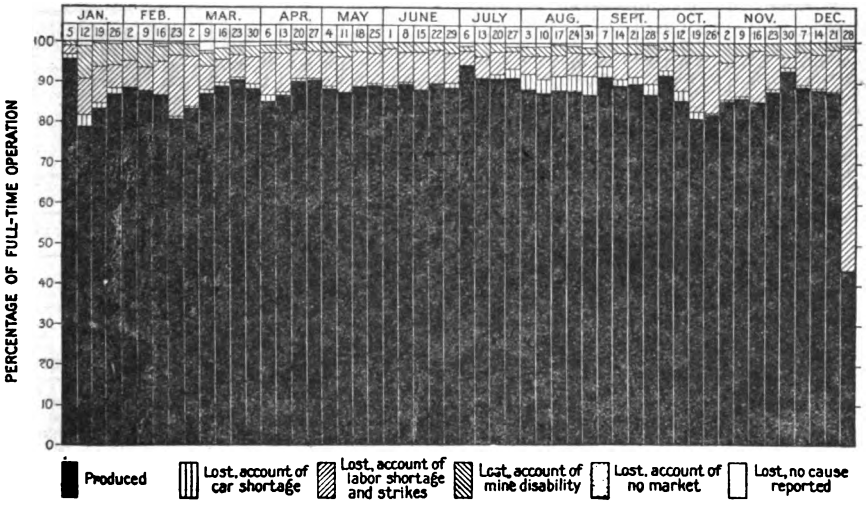

FIGURE 76.—Percentage of full-time operation of coal mines and of losses of running time, by causes and by weeks, in Alabama, in 1918.

with 28,386 men in 1917, a decrease of 8 per cent. Although the working day was in February, 1918, reduced from 9 and 10 hours to 8 hours, there appears to have been no serious curtailment as a result. The average output per man per day in 1918 was 2.63 tons, a slight gain over the record of 2.59 tons in 1917. The average number of days worked increased slightly, from 273 in 1917 to 278 in 1918, and the annual output per employee increased from 707 tons to 732 tons. The decrease in number of men employed was almost entirely among those working underground.

The largest decrease in production was in Jefferson County, the largest producing county in the State. Walker County, the second in importance, had an increase, as did Blount and Winston counties.

The average value per ton was $2.85 in 1918, as compared with $2.27 in 1917, and with a calculated average on the basis of the Fuel Administration prices of $2.67. The actual average return of $2.85 per ton compares with the estimated average price of the Fuel Administration of $2.83 in the last quarter of the year.

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Reports of production and of working time made weekly by the operators to the Geological Survey and the Fuel Administration recorded the percentage of full-time operation and the percentages of losses by causes. These data are shown graphically in the accompanying diagram (fig. 76). According to this record the operators in Alabama enjoyed in 1918 more nearly continuous operation than in any other district of comparable size in the country.

Coal produced in Alabama in 1917.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used be employees (net tons).	Used at mines for steam and heat (net tons).	Made into coke at mines (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
						Underground.	Surface.	Total.	
Bibb	1,514,154	12,358	98,111	.....	1,624,623	1,999	547	2,546	277
Blount	257,159	3,700	5,870	.....	266,729	423	122	545	206
Etowah	150,153	1,918	2,194	.....	154,265	197	41	238	271
Jefferson	7,089,174	229,060	300,555	2,834,304	10,453,093	11,746	2,731	14,477	291
St. Clair	813,070	3,406	20,519	.....	836,995	643	91	734	290
Shelby	731,082	6,847	43,929	.....	781,858	1,161	309	1,470	256
Tuscaloosa	193,800	87,528	36,642	605,765	923,735	1,227	315	1,542	240
Walker	4,364,113	151,560	123,649	205,158	4,844,480	5,170	1,193	6,363	248
Winston	43,456	444	.....	.....	43,900	118	20	138	176
Other counties[a]	116,555	3,111	10,264	.....	129,930	241	92	333	223
Small mines	.....	8,466	.....	.....	8,466	.....	.....	.....	.....
	15,272,716	508,398	641,733	3,645,227	20,068,074	22,925	5,461	28,386	273

[a] Cullman, Jackson, and Marion.

Value of coal produced in Alabama in 1917.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Made into coke at mines.	Total value.	Average value per ton.
Bibb	$3,669,103	$31,561	$224,880	.....	$3,925,544	$2.42
Blount	659,832	9,300	16,748	.....	685,880	2.57
Etowah	320,239	3,702	4,523	.....	328,464	2.13
Jefferson	15,445,288	382,805	653,963	$8,167,903	24,649,959	2.36
St. Clair	1,560,721	6,764	30,320	.....	1,597,805	1.91
Shelby	2,038,669	19,034	119,532	.....	2,177,235	2.78
Tuscaloosa	453,778	190,742	68,182	1,234,479	1,947,181	2.11
Walker	8,786,741	347,490	198,182	470,145	9,802,558	2.02
Winston	124,307	1,100	.....	.....	125,407	2.86
Other counties[a]	332,817	7,851	15,525	.....	356,193	2.74
Small mines	.....	20,766	.....	.....	20,766	2.45
	33,391,495	1,021,115	1,331,855	9,872,527	45,616,992	.....
Average value per ton	2.19	2.01	2.08	2.71	2.27	2.27

[a] Cullman, Jackson, and Marion.

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Coal produced in Alabama in 1918.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Made into coke at mines (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
						Underground.	Surface.	Total.	
Bibb	1,294,288	12,655	67,605	.....	1,374,548	1,674	438	2,112	267
Blount	301,158	4,155	9,582	.....	315,095	340	160	500	280
Etowah	126,032	1,661	2,845	.....	130,538	196	41	237	290
Jefferson	7,261,492	96,540	275,792	1,746,133	9,379,957	10,199	2,523	12,722	290
St. Clair	779,017	6,635	27,855	18,841	832,348	576	240	816	296
Shelby	695,127	8,216	40,768	.....	744,111	961	219	1,180	283
Tuscaloosa	690,719	10,026	27,331	304,629	1,032,705	1,014	385	1,399	280
Walker	4,715,284	159,283	126,111	155,591	5,156,269	5,264	1,499	6,763	260
Winston	73,707	120	2,700	.....	76,527	101	47	148	233
Other counties [a]	124,967	2,483	13,150	.....	140,600	259	85	344	220
Small mines	.....	2,264	.....	.....	2,264	.....	.....	.....	.....
	16,061,991	304,038	593,739	2,225,194	19,184,962	20,584	5,637	26,221	278

[a] Cullman, Jackson, and Marion.

Value of coal produced in Alabama in 1918.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Made into coke at mines.	Total value.	Average value per ton.
Bibb	$4,209,392	$38,637	$175,097	.....	$4,423,126	$3.22
Blount	950,847	11,539	28,274	.....	990,660	3.14
Etowah	399,863	4,821	8,251	.....	412,935	3.16
Jefferson	18,825,779	222,121	1,057,949	$6,683,093	26,788,942	2.86
St. Clair	2,119,176	16,993	62,636	69,712	2,267,517	2.72
Shelby	2,373,773	29,544	132,330	.....	2,535,647	3.41
Tuscaloosa	2,179,603	36,885	61,308	843,665	3,121,461	3.02
Walker	12,409,841	326,935	293,103	442,245	13,472,124	2.61
Winston	250,323	414	9,180	.....	259,917	3.40
Other counties [a]	419,825	18,140	36,744	.....	474,709	3.38
Small mines	.....	5,291	.....	.....	5,291	2.34
	44,138,422	710,320	1,864,872	8,038,715	54,752,329	.....
Average value per ton	2.75	2.34	3.14	3.61	2.85	2.85

[a] Cullman, Jackson, and Marion.

Coal produced in Alabama, 1914–1918, in net tons.

County.	1914	1915	1916	1917	1918	Increase or decrease, 1918.
Bibb	1,674,846	1,534,534	1,493,856	1,624,623	1,374,548	− 250,075
Blount	150,384	165,739	[a] 212,111	266,729	315,095	+ 48,366
Cullman, Jackson, and Marion	81,041	[b] 68,890	[b] 80,158	129,930	140,600	+ 10,670
Etowah	156,909	177,368	158,601	154,265	130,538	− 23,727
Jefferson	7,936,145	7,579,503	9,834,869	10,453,093	9,379,957	− 1,073,136
St. Clair	752,588	774,058	792,170	836,995	832,348	− 4,647
Shelby	498,914	589,412	618,638	781,858	744,111	− 37,747
Tuscaloosa	858,899	787,586	940,796	923,735	1,032,705	+ 108,970
Walker	3,450,185	3,221,955	3,932,023	4,844,480	5,156,269	+ 311,789
Winston	31,618	26,627	22,415	43,900	76,527	+ 32,627
Small mines	1,893	[a] 2,265	560	8,466	2,264	− 6,202
	15,593,422	14,927,937	18,096,197	20,068,074	19,184,962	− 883,112
Total value	$20,849,919	$19,066,043	$24,859,831	$45,616,992	$54,752,329	+ $9,135,337

[a] Includes Jackson County.

[b] Marion County only.

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ALASKA.[1]

The production of coal in Alaska in 1918 was 75,606 tons, valued at $411,850, compared with 53,955 tons, valued at about $265,317, in 1917. This production was by far the largest in the history of coal mining in Alaska, being 40 per cent larger than the output for 1917, which was also greater than that of any previous year. It is believed that a substantial coal-mining industry has at last begun in Alaska. The larger part of the output in 1918 came from the Matanuska field, which produced 63,092 tons. The remainder came from eight or ten small mines in various parts of the Territory. All these mines, except in the Matanuska and Bering River fields and at Port Graham, produced coal for local use under free-use permits.

In the Matanuska field the Eska Creek mines were operated regularly throughout the year by the Alaskan Engineering Commission to supply fuel for railroad and other Government use. At the Chickaloon mine, also operated by the Alaskan Engineering Commission, the work has consisted primarily of exploration and development, and only a small quantity of coal, won incidentally, has been produced. In 1918 for the first time Matanuska coal was shipped beyond Anchorage. Private operations preparatory to mining were continued by two lessees in the Matanuska field and some coal was mined by one of them, but their mines are not yet regularly productive.

The lignite fields of the Cook Inlet-Susitna district rank next to the Matanuska coal fields in point of production for 1918. A considerable quantity of lignite that was mined near Bluff Point was shipped to towns and canneries on Cook Inlet. A lignite mine on Cache Creek, in the Yentna district, was operated during part of the year to supply fuel for a gold dredge. The Little Susitna mine supplied part of the fuel for the town of Anchorage. It is reported that some coal was mined at Port Graham.

In the Nenana field no leases have yet been granted, but two small mines were opened under mining permits and a small quantity of lignite was mined for use in the construction of the railroad.

It is reported that in the Bering River field the railroad has been extended from its temporary terminus on Bering River to the mine of the Alaska Petroleum & Coal Co. in the eastern part of the field and that small shipments of semianthracite coal were made late in the year. A lease was granted in 1918 to another company for a tract of semibituminous coal land in the western part of the field, and it is reported that extensive operations preparatory to mining are being undertaken.

In northern Alaska lignite mined near Unalaklik, on Norton Sound, was shipped to Nome and St. Michael, and lignite mined on Kobuk River was shipped to Kotzebue. It was reported that lignite would be mined on Kugruk River, Seward Peninsula, during the winter of 1918–19 for use at the placer mines on the Inmachuk.

The following tables give the estimated production of coal in Alaska since 1888. The production for 1888 to 1896 is estimated from the best data available but is only approximate. The figures for 1897 to 1918 are based for the most part on data supplied by the operators. Most of the coal mined before 1916 was lignite. There was a small production of bituminous coal from the west end of the Bering

[1] Martin, G. C., The Alaskan mining industry in 1918: U. S. Geol. Survey Bull. 712, pp. 24–26, 1919.

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River field in 1906. The table does not include 855 tons of coal mined in the Bering River field in 1912 and 1,100 tons mined in the Matanuska field in 1913 for test by the United States Navy.

Coal produced in Alaska, 1888–1918.

Year.	Quantity (short tons).	Value.	Year.	Quantity (short) tons).	Value.
1888–1896	6,000	$84,000	1909	2,800	$12,300
1897	2,000	28,000	1910	1,000	15,000
1898	1,000	14,000	1911	900	9,300
1899	1,200	16,800	1912	355	2,840
1900	1,200	16,800	1913	2,300	13,800
1901	1,300	15,600	1914		
1902	2,212	19,048	1915	1,400	3,300
1903	1,447	9,782	1916	13,073	52,317
1904	1,694	7,225	1917	53,955	265,317
1905	3,774	13,250	1918	75,606	411,850
1906	5,541	17,974		192,003	1,096,913
1907	10,139	53,600			
1908	3,107	14,810			

The following table shows the consumption of coal in Alaska, including both local production and imports, since 1899. Most of the coal shipped to Alaska was bituminous, but a little was anthracite.

Coal consumed in Alaska, 1899–1918, in short tons.

Year.	Produced in Alaska, chiefly subbituminous and lignite.	Imported from States, chiefly bituminous from Washington.	Total foreign coal, chiefly bituminous from British Columbia.	Total coal consumed.
1899	1,200	10,000	[a] 50,120	61,320
1900	1,200	15,048	[a] 56,623	72,871
1901	1,300	24,000	[a] 77,674	102,974
1902	2,212	40,000	[a] 68,363	110,575
1903	1,447	64,626	[a] 60,605	126,678
1904	1,694	36,689	[a] 76,815	115,198
1905	3,774	67,713	[a] 72,612	144,099
1906	5,541	69,493	[a] 47,590	122,624
1907	10,139	46,246	[a] 93,262	149,647
1908	3,107	23,893	[a] 86,404	113,404
1909	2,800	33,112	69,046	104,958
1910	1,000	32,098	58,420	91,518
1911	900	32,255	61,845	95,000
1912	355	27,767	68,316	96,438
1913	2,300	69,066	56,430	127,796
1914		41,509	46,153	87,662
1915	1,400	46,329	29,457	77,186
1916	13,073	44,934	53,672	111,679
1917	53,955	58,116	56,589	168,660
1918	75,606	51,520	37,986	165,112
	183,003	834,414	1,227,982	2,245,399

[a] Fiscal year ending June 30.

ARKANSAS.

Each of the important coal producing counties in Arkansas recorded gains in 1918 compared with 1917, the output for the State, 2,227,369 tons, representing an increase over 1917 of 83,790 tons, or 3.9 per cent. The strong demand for high-grade domestic coal in the Western States from which Pennsylvania anthracite was diverted by the Fuel Administration in 1918, resulted in a substantial gain in the output from the

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"Arkansas anthracite" mines in Franklin and Johnson counties. The number of days worked increased from 187 in 1917 to 204 in 1918, and the average number of men employed remained about the same—3,978 in 1918 as against 3,998 in 1917.

Coal produced in Arkansas in 1917.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
					Underground.	Surface.	Total.	
Franklin	196,919	3,567	9,666	210,152	308	47	355	162
Johnson	283,690	10,564	12,694	306,948	541	221	762	167
Logan	40,622	4,554	1,774	46,950	119	19	138	179
Sebastian	1,371,956	14,321	47,078	1,433,355	1,843	435	2,278	194
Other counties [a]	116,221	7,468	3,855	127,544	324	141	465	207
Small mines	.....	18,630	.....	18,630	.....	.....	.....	.....
	2,009,408	59,104	75,067	2,143,579	3,135	863	3,998	187

[a] Ouachita, Pope, Scott, and Washington.

Value of coal produced in Arkansas in 1917.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Total value.	Average value per ton.
Franklin	$538,154	$9 346	$24,654	$572,154	$2.72
Johnson	984,473	40,262	33,795	1,058,530	3.45
Logan	139,413	11,887	4,977	156,277	3.38
Sebastian	3,034,870	34,921	91,746	3,161,537	2.21
Other counties [a]	451,876	39,657	7,975	499,508	3.92
Small mines	.....	44,771	.....	44,771	2.40
	5,148,786	180,844	163,147	5,492,777	.....
Average value per ton	2.56	3.06	2.17	2.56	2.56

[a] Ouachita, Pope, Scott, and Washington.

Coal produced in Arkansas, 1918.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
					Underground.	Surface.	Total.	
Franklin	220,732	3,836	15,581	240,149	317	85	402	214
Johnson	354,742	5,544	11,418	371,704	626	313	939	165
Logan	41,501	6,413	1,454	49,368	114	30	144	178
Sebastian	1,388,660	16,154	42 454	1,447,268	1,805	370	2,175	213
Other counties [a]	106,357	3,322	3,013	112,692	245	73	318	254
Small mines	.....	6,188	.....	6,188	.....	.....	.....	.....
	2,111,992	41,457	73,920	2,227,369	3,107	871	3,978	204

[a] Pope and Scott.

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Value of coal produced in Arkansas in 1918.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Total value.	Average value per ton.
Franklin	$758,210	$13,971	$44,963	$817,144	$3.40
Johnson	1,527,269	24,960	36,457	1,588,686	4.27
Logan	216,937	28,917	5,657	251,511	5.09
Sebastian	4,620,145	50,259	125,459	4,795,863	3.31
Other counties [a]	659,157	18,742	18,440	696,339	6.18
Small mines	.....	22,833	.....	22,833	3.60
	7,781,718	159,682	230,976	8,172,376	.....
Average value per ton	3.68	3.85	3.12	3.67	3.67

[a] Pope and Scott.

Coal produced in Arkansas, 1914–1918, in net tons.

County.	1914	1915	1916	1917	1918	Increase or decrease, 1918.
Franklin	168,746	190,237	243,118	210,152	240,149	+ 29,997
Johnson	148,845	176,457	243,774	306,948	371,704	+ 64,756
Logan	7,172	29,505	42,128	46,950	49,368	+ 2,418
Pope, Scott, and Washington	[a] 88,047	93,517	103,773	[a] 127,544	[b] 112,692	— [b] 14,852
Sebastian	1,423,202	1,153,494	1,352,402	1,433,355	1,447,268	+ 13,913
Small mines	528	8,996	9,720	18,630	6,188	— 12,442
	1,836,540	1,652,106	1,994,915	2,143,579	2,227,369	+ 83,790
Total value	$3,158,168	$2,950,456	$3,836,845	$5,492,777	$8,172,376	+$2,679,599

[a] Includes Ouachita County. [b] No production in Washington County.

CALIFORNIA AND IDAHO.

The production of coal, bituminous and lignite, in California and Idaho in 1918 was 6,400 tons, approximately the same as in 1917. The statistics for Idaho are combined with those for California in order not to reveal the operations of the two producers, both small, in Idaho.

Coal produced in California, 1911–1913, in California, Idaho, and Nevada in 1914 and 1915, and in California and Idaho in 1916, 1917, and 1918.

Year.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Total quantity (net tons).	Total value.	Average value per ton.	Number of employees.	Average number of days worked.
1911	4,981	5,266	500	10,747	$16,097	$1.50	45	254
1912	3,748	3,630	3,600	10,978	23,601	2.15	52	184
1913	14,864	1,808	8,167	24,839	84,073	3.38	35	332
1914	4,200	9,174	600	13,974	39,821	2.85	43	291
1915	2,488	9,715	300	12,503	32,054	2.56	36	285
1916	1,593	4,647	1,000	7,240	15,367	2.12	18	188
1917	2,800	3,383	240	6,423	14,791	2.30	17	173
1918	5,800	600	.....	6,400	17,250	2.70	15	240

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COLORADO.

Colorado, the largest coal-producing State west of Mississippi River and the eighth in rank in the United States, had a production in 1918 of 12,407,571 tons, a slight decrease (75,765 tons, or 0.6 per cent) as compared with 1917. The lignite districts in the northern part of the State (Boulder and Weld counties) increased their output, but the lignite mines in El Paso County had a decrease in production. The production of bituminous coal in the Trinidad field increased, and a decrease of 109,553 tons in Las Animas County was more than offset by an increase of 175,471 tons in Huerfano County. There was practically no change in Fremont County (the Canon City field), but the production in Routt County decreased 132,748 tons, or 12 per cent, largely because of car shortage in the early months of the year. Compared with 1917 when 14,231 men worked an average of 263 days there were in 1918 14,483 men who worked an average of 255 days.

Coal produced in Colorado in 1917.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Made into coke at mines (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
						Underground.	Surface.	Total.	
Boulder	1,218,852	28,087	30,724	.....	1,277,663	1,033	156	1,189	241
Delta	82,581	11,969	19	.....	94,569	71	18	89	216
El Paso	314,694	48,041	8,431	.....	371,166	302	45	347	273
Fremont	788,078	63,526	20,242	.....	871,846	1,032	174	1,206	277
Garfield	93,915	6,278	4,270	.....	104,463	76	28	104	291
Gunnison	586,912	5,904	25,898	36,870	655,584	460	146	606	275
Huerfano	2,316,712	42,799	51,929	.....	2,411,440	2,352	879	3,231	265
Jackson and Jefferson	201,059	4,564	11,863	.....	217,486	321	83	404	248
La Plata	112,311	9,890	1,267	16,010	139,478	135	43	178	249
Las Animas	2,217,101	144,960	92,740	1,905,043	4,359,844	4,053	964	5,017	282
Mesa	169,924	9,298	.....	.....	179,222	175	18	193	233
Pitkin and Rio Blanco	22,964	3,729	.....	.....	26,693	30	13	43	170
Routt	1,033,015	5,835	35,253	.....	1,074,103	768	282	1,050	205
Weld	612,411	20,871	21,695	.....	654,977	471	97	568	223
Small mines[a]	.....	44,641	161	.....	44,802	6	.....	6	174
	9,770,529	450,392	304,492	1,957,923	12,483,336	11,285	2,946	14,231	263

[a] Includes Montrose and Ouray counties.

Value of coal produced in Colorado in 1917.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Made into coke at mines.	Total value.	Average value per ton.
Boulder	$2,695,445	$95,632	$55,374	.....	$2,846,451	$2.23
Delta	199,687	28,687	38	.....	228,412	2.42
El Paso	591,500	96,175	9,719	.....	697,394	1.88
Fremont	2,217,906	175,953	26,401	.....	2,420,260	2.78
Garfield	179,347	13,680	5,934	.....	198,961	1.90
Gunnison	1,236,441	11,948	33,763	$53,097	1,335,249	2.04
Huerfano	5,904,855	72,340	103,630	.....	6,080,825	2.52
Jackson and Jefferson	386,084	13,339	17,408	.....	416,831	1.92
La Plata	246,055	22,465	2,348	44,828	315,696	2.26
Las Animas	4,628,570	326,862	132,936	3,361,732	8,450,100	1.94
Mesa	366,048	28,838	.....	.....	394,886	2.20
Pitkin and Rio Blanco	62,921	10,218	.....	.....	73,139	2.74
Routt	2,699,432	15,309	51,726	.....	2,766,467	2.58
Weld	1,251,335	52,334	38,141	.....	1,341,810	2.05
Small mines[a]	.....	102,487	161	.....	102,648	2.29
	22,665,626	1,066,267	477,579	3,459,657	27,669,129	.....
Average value per ton	2.32	2.37	2.55	1.77	2.22	2.22

[a] Includes Montrose and Ouray counties.

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Coal produced in Colorado in 1918.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Made into coke at mines (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
						Underground.	Surface.	Total.	
Boulder	1,244,158	72,330	43,773	.....	1,360,261	1,134	188	1,322	256
Delta	74,495	14,802	179	.....	89,476	67	25	92	189
El Paso	219,051	75,049	7,547	.....	301,647	232	40	272	237
Fremont	795,281	57,221	18,824	.....	871,326	995	193	1,188	282
Garfield	86,069	2,792	3,794	.....	92,655	95	50	145	171
Gunnison	582,906	6,930	26,657	36,278	652,770	467	173	640	257
Huerfano	2,493,842	41,225	51,844	.....	2,586,911	2,358	838	3,196	270
Jackson, Pitkin, and Rio Blanco	91,125	4,929	2,024	.....	98,078	37	26	63	212
Jefferson	113,032	3,189	10,109	.....	126,330	125	39	164	174
La Plata	98,820	23,963	1,093	15,087	138,963	345	33	378	265
Las Animas	3,078,332	63,251	80,660	1,028,048	4,250,291	3,982	1,030	5,012	281
Mesa	173,417	17,026	600	.....	191,043	193	67	260	243
Routt	893,210	6,248	41,897	.....	941,355	724	311	1,035	146
Weld	637,074	28,527	22,008	.....	687,609	566	150	716	181
Small mines[a]	.....	18,856	.....	.....	18,856	.....	.....	.....	.....
	10,580,811	436,338	311,009	1,079,413	12,407,571	11,320	3,163	14,483	255

[a] Includes Montrose and Ouray counties.

Value of coal produced in Colorado in 1918.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Made into coke at mines.	Total value.	Average value per ton.
Boulder	$3,176,162	$209,699	$107,322	.....	$3,493,183	$2.57
Delta	193,687	32,839	539	.....	227,065	2.54
El Paso	149,860	193,660	18,428	.....	361,948	1.20
Fremont	2,535,093	174,383	36,817	.....	2,746,293	3.15
Garfield	192,616	8,638	11,329	.....	212,583	2.29
Gunnison	1,624,729	21,860	52,879	$67,772	1,767,240	2.71
Huerfano	7,759,645	75,714	125,929	.....	7,961,288	3.08
Jackson, Pitkin, and Rio Blanco	220,679	12,478	3,426	.....	236,583	2.41
Jefferson	280,871	10,760	32,242	.....	323,873	2.56
La Plata	249,387	65,932	2,504	42,002	359,825	2.59
Las Animas	7,709,662	148,758	163,334	2,851,887	10,873,641	2.56
Mesa	485,266	57,484	1,540	.....	544,290	2.85
Routt	2,610,889	18,218	92,356	.....	2,721,463	2.89
Weld	1,399,981	78,146	47,412	.....	1,525,539	2.22
Small mines[a]	.....	49,929	.....	.....	49,929	2.65
	28,588,527	1,158,498	696,057	2,961,661	33,404,743	.....
Average value per ton	2.70	2.66	2.24	2.74	2.69	2.69

[a] Includes Montrose and Ouray counties.

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Coal produced in Colorado, 1914–1918, in net tons.

County.	1914	1915	1916	1917	1918	Increase or decrease, 1918.
Archuleta and Montezuma	3,775	2,375	(a)			
Boulder	1,000,590	946,888	1,067,539	1,277,663	1,360,261	+ 82,598
Delta	86,861	69,053	70,696	94,569	89,476	− 5,093
El Paso	280,577	299,883	312,670	371,166	301,647	− 69,519
Fremont	169,271	473,284	605,108	871,846	871,326	− 520
Garfield	112,842	139,393	133,771	104,463	92,655	− 11,808
Gunnison	402,045	439,403	512,265	655,584	652,770	− 2,814
Huerfano	1,724,265	1,682,335	1,884,943	2,411,440	2,586,911	+ 175,471
Jackson and Jefferson	188,080	152,498	185,704	217,486	b 224,408	b − 19,771
La Plata	132,317	117,502	108,603	139,478	138,963	− 515
Las Animas	2,693,288	2,853,847	4,042,937	4,359,844	4,250,291	− 109,553
Mesa	163,894	101,327	132,111	179,222	191,043	+ 11,821
Pitkin and Rio Blanco	65,104	52,143	42,861	26,693	(b)	(b)
Routt	666,384	852,315	915,028	1,074,103	941,355	− 132,748
Weld	475,734	432,501	464,959	654,977	687,609	+ 32,632
Small mines	5,532	10,233	c 15,042	c 44,802	c 18,856	c − 25,946
Total value	8,170,559 $13,601,718	8,624,980 $13,599,264	10,484,237 $16,964,104	12,483,336 $27,660,129	12,407,571 $33,404,743	− 75,765 +$5,735,614

a Small mines include Montezuma County.
b Jackson and Jefferson include Pitkin and Rio Blanco.
c Includes Montrose and Ouray.

GEORGIA.

The two companies operating coal mines in Georgia (both of whom have kindly granted permission for the publication of their combined statistics as the State totals) had a production in 1918 of 66,716 tons, compared with 119,028 tons in 1917. The decrease was apparently largely due to lack of men, the total number of employees decreasing by 32 per cent.

Coal produced in Georgia, 1914, 1915, 1916, 1917, and 1918.

Year.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Made into coke at mines (net tons).	Total quantity (net tons).	Total value.	Average value per ton.	Number of employees.	Average number of days worked.
1914	85,645	1,400	7,900	45,298	140,243	$239,462	$1.71	355	207
1915	90,523	1,396	7,200	35,377	134,496	231,861	1.72	368	197
1916	76,954	1,672	7,200	87,728	173,554	310,093	1.79	411	280
1917	37,855	1,284	7,200	72,689	119,028	301,391	2.53	261	269
1918	21,725	888	6,250	37,853	66,716	239,377	3.59	190	258

ILLINOIS.

A new high record for production of coal in Illinois was established in 1918 by an output of 89,291,105 tons, an increase over the previous high record of 1917 of 3,091,718 tons, or 3.6 per cent. By far the greater part of this increase came from the three southern counties, Franklin, Williamson, and Saline, in which is produced the highest-grade coal in Illinois. The central or Springfield district also had an increase, as did the Bellville and Danville districts, but the northern and Fulton-Peoria districts recorded decreases. The proportionately large increase obtained in the southern field was made possible by the

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developments in the last few years and because of the need and demand for the excellent coal from this field to fill the requirements of consumers who were denied the higher grades of eastern coal by the zoning system. The following table shows in a general way the relative progress of the principal producing districts in Illinois from 1916 to 1918. As the totals given were arrived at by combining county totals and not all the counties in the State are included and because the fields described are not actually defined by county lines, the following record must be considered as relative rather than as representing the actual production in these well-known trade and rate districts.

Production of coal in Illinois, by groups of principal counties, 1916–1918, in net tons.

Field.	County.	1916	1917	1918
Northern	Grundy, Will, La Salle, Bureau, and Putnam	3,458,000	3,738,000	3,215,000
Danville	Vermilion	2,834,000	3,886,000	3,973,000
Fulton-Peoria	Tazewell, Rock Island, Fulton, and Knox	4,203,000	5,215,000	4,663,000
Central	Logan, Macon, Christian, Montgomery, Menard, Moultrie, Macoupin, and Sangamon	17,234,000	23,848,000	24,519,000
Belleville	Madison, Bond, St. Clair, Monroe, Randolph, Perry, Marion, and Jefferson.	12,872,000	17,716,000	18,758,000
Southern	Franklin, Williamson, Saline, and Gallatin	21,686,000	27,363,000	29,623,000

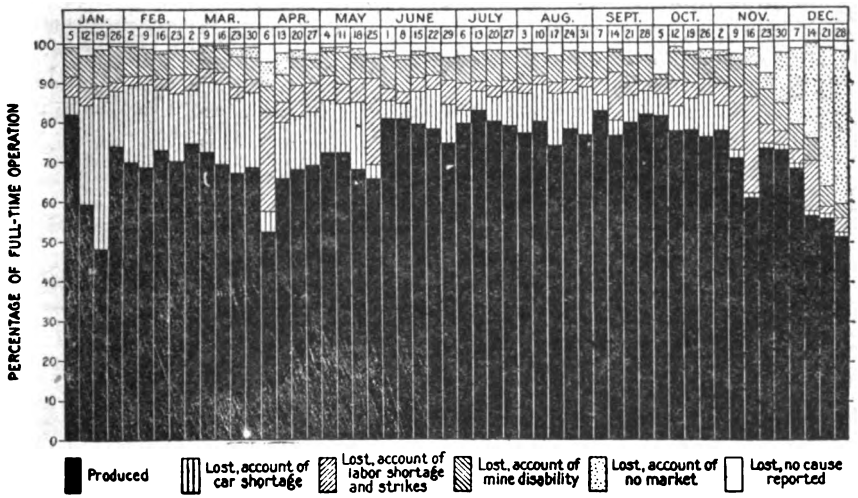

FIGURE 77.—Percentage of full-time operation of coal mines and of losses of running time, by causes and by weeks, in Illinois, in 1918.

The average number of days worked decreased from 243 in 1917 to 238 in 1918 and the number of men increased slightly from 84,090 to 85,965. The average daily output per man, however, increased from 4.22 tons in 1917 to 4.37 tons in 1918, and by reason of the greater effectiveness of the labor the total production for the State was increased. Had not the demand fallen off in the last quarter of the year an even larger production would have been attained.

The weekly statistics of operation, shown graphically in figure 77, indicate that largely because of lack of cars the mines in Illinois aver-

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aged only about 70 per cent of full running time in the first five months of 1918, and that from June to the end of October the average was increased to nearly 80 per cent. Because of no market, mainly lack of demand for steam coal, which affected the central and neighboring fields, the production declined in November and December to less than 60 per cent.

Coal produced in Illinois in 1917.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
					Underground.	Surface.	Total.	
Bond and White	263,085	17,624	11,194	291,903	227	26	253	233
Bureau	1,237,589	75,004	50,769	1,363,362	2,425	204	2,629	285
Christian	2,939,888	128,035	65,437	3,133,360	2,573	279	2,852	242
Clinton	1,315,869	87,209	61,644	1,464,722	1,435	133	1,568	203
Franklin	11,055,327	93,112	306,799	11,455,238	9,144	1,339	10,483	217
Fulton	2,607,467	114,893	98,135	2,820,495	2,879	320	3,199	202
Gallatin and Johnson	64,828	7,225	2,684	74,737	84	16	100	227
Greene, McDonough, Moultrie, and Stark	237,737	19,768	10,501	268,006	231	21	252	243
Grundy	382,042	18,230	17,761	418,033	656	65	721	267
Hancock, Scott, and Warren	.....	9,410	.....	9,410	29	.....	29	207
Henry	.....	47,911	2,121	50,032	82	10	92	259
Jackson	693,341	86,445	27,374	807,160	835	166	1,001	205
Knox	75	13,125	850	14,050	21	4	25	212
La Salle	768,300	174,494	208,362	1,151,156	1,275	240	1,515	273
Livingston	40,557	79,772	5,034	125,363	141	28	169	263
Logan	470,395	99,430	29,919	599,744	660	78	738	257
McLean, Putnam, Will, and Woodford	915,653	121,075	52,689	1,089,417	1,654	177	1,831	282
Macon	103,745	186,136	18,172	308,053	496	45	541	252
Macoupin	6,768,331	142,243	159,572	7,070,146	5,607	528	6,135	248
Madison	5,080,675	163,982	119,594	5,364,251	4,038	386	4,424	248
Marion	1,078,087	20,415	21,924	1,120,426	1,013	113	1,126	227
Marshall	315,889	95,978	25,220	437,087	728	81	809	297
Menard	163,066	44,731	5,681	213,478	220	26	246	257
Mercer	231,119	21,496	16,176	268,791	316	48	364	235
Montgomery	4,098,210	43,106	63,406	4,204,722	3,216	448	3,664	238
Peoria	1,392,783	132,120	23,013	1,547,916	1,499	168	1,667	283
Perry	2,567,623	104,232	68,059	2,739,914	2,574	283	2,857	205
Randolph	1,335,249	25,771	36,609	1,397,629	1,216	118	1,334	224
Rock Island	.....	53,593	1,489	55,082	52	9	61	205
St. Clair	6,399,749	330,588	225,429	6,955,766	5,549	729	6,278	225
Saline	5,027,201	48,330	113,246	5,188,777	4,967	493	5,460	238
Sangamon	7,555,314	346,029	161,392	8,062,735	6,708	608	7,316	264
Schuyler	.....	8,060	.....	8,060	18	1	19	167
Shelby	101,873	22,018	8,700	132,591	203	32	235	177
Tazewell	414,906	85,071	8,238	508,215	499	67	566	273
Vermilion	3,631,877	207,241	47,362	3,886,480	3,077	477	3,554	277
Washington	736,874	51,664	24,025	812,563	653	54	707	277
Williamson	10,288,621	81,406	275,670	10,645,697	8,085	1,185	9,270	231
Small mines	.....	134,820	.....	134,820	.....	.....	.....	.....
	80,283,345	3,541,792	2,374,250	86,199,387	75,085	9,005	84,090	243

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Value of coal produced in Illinois in 1917.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Total value.	Average value per ton.
Bond and White	$517,204	$37,270	$16,303	$570,777	$1.96
Bureau	2,993,660	193,563	77,539	3,264,762	2.39
Christian	4,671,560	265,175	97,174	5,033,909	1.61
Clinton	2,234,360	150,390	93,392	2,478,142	1.69
Franklin	24,129,079	205,434	491,696	24,826,209	2.17
Fulton	5,454,541	228,543	159,382	5,842,466	2.07
Gallatin and Johnson	143,312	14,298	5,092	162,702	2.18
Greene, McDonough, Moultrie, and Stark	456,091	55,025	14,725	525,841	1.96
Grundy	1,047,478	55,971	33,423	1,136,372	2.72
Hancock, Scott, and Warren	.....	27,316	.....	27,316	2.90
Henry	.....	119,015	3,025	122,040	2.44
Jackson	1,436,030	196,815	44,546	1,677,391	2.08
Knox	131	31,482	1,850	33,463	2.38
La Salle	1,877,336	460,822	486,159	2,824,317	2.45
Livingston	94,613	198,209	9,336	302,158	2.41
Logan	986,361	207,114	51,885	1,245,360	2.08
McLean, Putnam, Will, and Woodford	1,821,185	396,318	107,042	2,324,545	2.13
Macon	267,294	499,972	41,079	808,345	2.62
Macoupin	10,821,414	279,370	167,679	11,268,463	1.59
Madison	8,376,251	311,381	179,895	8,867,527	1.65
Marion	2,287,061	38,242	34,396	2,359,699	2.11
Marshall	818,692	264,993	50,583	1,134,268	2.60
Menard	296,164	115,790	11,247	423,201	1.98
Mercer	480,312	49,606	28,982	559,400	2.08
Montgomery	7,775,173	98,509	100,349	7,974,031	1.90
Peoria	2,722,379	267,744	36,843	3,026,966	1.96
Perry	4,858,542	238,911	111,553	5,209,006	1.90
Randolph	2,271,521	41,476	48,477	2,361,474	1.69
Rock Island	.....	112,082	2,170	114,252	2.07
St. Clair	10,990,799	619,214	341,300	11,951,313	1.72
Saline	9,079,035	91,662	166,944	9,337,641	1.80
Sangamon	12,842,535	694,079	232,091	13,768,705	1.71
Schuyler	.....	16,610	.....	16,610	2.06
Shelby	228,020	68,151	17,619	313,790	2.37
Tazewell	834,247	172,578	17,456	1,024,281	2.02
Vermilion	6,683,983	311,259	74,635	7,069,377	1.82
Washington	1,355,072	109,584	35,956	1,500,612	1.85
Williamson	19,895,459	161,865	435,700	20,493,024	1.93
Small mines	.....	301,067	.....	301,067	2.23
	150,747,394	7,706,905	3,827,523	162,281,822	.....
Average value per ton	1.88	2.18	1.61	1.88	1.88

Coal produced in Illinois in 1918.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked
					Underground.	Surface.	Total.	
Bond and White	341,921	23,858	15,090	380,869	354	25	379	245
Bureau	1,057,949	73,725	49,523	1,181,197	1,714	285	1,999	276
Christian	3,130,120	139,566	70,691	3,340,377	2,584	293	2,877	228
Clinton	1,395,797	86,954	50,951	1,533,702	1,384	149	1,533	210
Franklin	11,880,427	123,300	369,629	12,373,356	9,275	1,943	11,218	220
Fulton	2,390,519	82,796	78,790	2,552,105	2,744	322	3,066	240
Gallatin and Johnson	207,793	10,441	9,210	227,444	214	38	252	221
Greene, McDonough, Moultrie, and Stark	200,581	15,751	11,905	228,237	206	20	226	237
Grundy	285,929	15,381	16,491	317,801	370	87	457	235
Hancock, Scott, and Warren	.....	2,913	.....	2,913	11	.....	11	152
Henry	.....	39,637	1,695	41,332	68	8	76	292
Jackson	886,901	129,895	38,429	1,055,225	958	248	1,206	227
Knox	.....	6,869	800	7,669	21	4	25	193
La Salle	706,078	331,750	46,051	1,083,879	1,275	416	1,691	271
Livingston	25,792	74,473	5,076	105,341	132	30	162	236
Logan, McLean, Putnam, Will, and Woodford	1,002,245	235,896	71,595	1,309,736	1,705	339	2,044	268
Macon	118,752	209,371	19,277	347,400	415	40	455	266
Macoupin	7,130,626	81,874	168,665	7,381,165	5,941	592	6,533	244
Madison	4,820,571	136,081	117,731	5,074,383	3,953	424	4,377	239
Marion	1,061,749	21,932	35,525	1,119,206	883	92	975	265

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Coal produced in Illinois in 1918—Continued.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
					Underground.	Surface.	Total.	
Marshall	222,627	62,731	25,426	310,784	584	85	669	267
Menard	158,508	39,480	5,489	203,477	194	23	217	265
Mercer	267,713	14,597	15,133	287,443	310	44	354	183
Montgomery	4,099,379	53,518	78,225	4,231,122	3,489	335	3,824	218
Peoria	1,148,236	126,865	20,559	1,295,460	1,289	204	1,493	247
Perry	2,683,943	128,467	105,180	2,917,590	2,469	307	2,776	225
Randolph	1,548,088	38,589	40,637	1,627,414	1,382	136	1,518	233
Rock Island	.....	34,723	1,345	36,068	44	6	50	205
St. Clair	7,266,076	311,998	232,112	7,810,186	6,173	874	7,047	231
Saline	5,454,661	74,353	155,580	5,684,594	5,184	598	5,782	251
Sangamon	7,809,564	367,432	154,768	8,331,764	6,923	672	7,595	260
Schuyler	150	6,854	.....	7,004	14	.....	14	283
Shelby	158,636	24,986	10,624	193,246	229	43	272	207
Tazewell	418,292	60,392	5,997	484,681	520	54	574	235
Vermilion	3,709,974	215,312	47,692	3,973,478	2,917	517	3,434	261
Washington	716,138	79,222	25,997	821,357	507	67	574	272
Williamson	10,973,129	86,124	279,309	11,338,562	8,835	1,375	10,210	230
Small mines	.....	73,438	.....	73,438	.....	.....	.....	.....
	83,268,864	3,641,044	2,381,197	89,291,105	75,270	10,695	85,965	238

Value of coal produced in Illinois in 1918.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Total value.	Average value per ton.
Bond and White	$772,170	$65,632	$30,028	$867,830	$2.28
Bureau	3,282,004	226,942	125,296	3,634,242	3.08
Christian	6,309,382	329,742	140,422	6,779,546	2.03
Clinton	3,089,256	193,636	105,841	3,388,733	2.21
Franklin	28,127,831	314,292	782,457	29,224,580	2.36
Fulton	6,272,493	210,546	179,081	6,662,120	2.61
Gallatin and Johnson	450,593	26,477	17,881	494,951	2.18
Greene, McDonough, Moultrie, and Stark	435,298	48,876	16,510	500,684	2.19
Grundy	938,533	57,643	44,881	1,041,057	3.28
Hancock, Scott, and Warren	.....	10,732	.....	10,732	3.68
Henry	.....	117,601	2,636	120,237	2.91
Jackson	2,293,686	255,552	75,290	2,624,528	2.49
Knox	.....	18,944	1,125	20,069	2.62
La Salle	2,194,808	977,846	126,324	3,298,978	3.04
Livingston	92,573	253,250	16,940	362,763	3.44
Logan, McLean, Putnam, Will, and Woodford	2,541,428	685,934	170,898	3,398,260	2.59
Macon	326,477	622,876	43,256	992,609	2.86
Macoupin	15,426,418	216,831	273,877	15,917,126	2.16
Madison	11,033,488	299,273	199,685	11,532,446	2.27
Marion	2,436,805	54,448	69,635	2,560,888	2.29
Marshall	956,080	283,519	82,429	1,322,028	4.25
Menard	369,476	102,245	10,092	481,813	2.37
Mercer	722,447	44,418	41,527	808,392	2.81
Montgomery	9,478,234	128,740	141,719	9,748,693	2.30
Peoria	3,011,357	324,874	43,321	3,379,552	2.61
Perry	6,031,982	307,128	186,196	6,525,306	2.24
Randolph	3,393,152	88,922	65,436	3,547,510	2.18
Rock Island	.....	78,815	2,263	81,078	2.25
St. Clair	15,483,860	694,594	429,383	16,607,837	2.13
Saline	13,017,929	184,153	276,777	13,478,859	2.37
Sangamon	17,264,108	888,984	273,436	18,426,528	2.21
Schuyler	150	15,048	.....	15,198	2.17
Shelby	415,391	88,695	21,465	525,551	2.72
Tazewell	1,103,423	152,872	12,474	1,268,769	2.62
Vermilion	8,453,890	457,572	105,816	9,017,278	2.27
Washington	1,624,489	191,293	41,959	1,857,741	2.26
Williamson	25,429,610	187,201	522,168	26,138,979	2.31
Small mines	.....	196,800	.....	196,800	2.68
	192,778,821	9,402,946	4,678,524	206,860,291	.....
Average value per ton	2.32	2.58	1.96	2.32	2.32

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Coal produced in Illinois, 1914–1918, in net tons.

County.	1914	1915	1916	1917	1918	Increase or decrease 1918.
Bond, Jefferson, Washington, and White	661,892	513,705	[a] 827,387	[a] 1,104,466	[a] 1,202,226	+ [a] 97,760
Bureau	1,284,311	1,202,698	1,340,018	1,363,362	1,181,197	− 182,165
Christian	1,486,053	2,135,052	2,516,336	3,133,360	3,340,377	+ 207,017
Clinton	1,090,787	1,315,648	1,307,712	1,464,722	1,533,702	+ 68,980
Franklin	7,311,209	8,027,773	9,388,292	11,455,238	12,373,356	+ 918,118
Fulton	2,052,170	1,849,906	2,190,950	2,820,495	2,552,105	− 268,390
Gallatin	81,735	77,380	[b] 20,398	[b] 74,737	[b] 227,444	+ [b] 152,707
Greene	6,665	5,764	2,963	[c] 268,006	[c] 228,237	− [c] 39,769
Grundy	388,368	293,660	324,794	418,033	317,801	− 100,232
Hancock, Morgan, Schuyler, Scott, and Warren	7,169	9,788	16,261	[d] 17,470	[d] 9,917	− [d] 7,553
Henry	47,010	46,219	44,502	50,032	41,332	− 8,700
Jackson	601,697	682,042	772,788	807,160	1,055,225	+ 248,065
Knox	14,150	11,985	9,897	14,050	7,669	− 6,381
La Salle	1,279,592	1,192,794	1,050,900	1,151,156	1,083,879	− 67,277
Livingston	64,461	63,341	110,709	125,363	105,341	− 20,022
Logan	352,181	311,346	465,159	599,744	(e)	(e)
McDonough	5,251	5,132	13,927	(c)	(c)	(c)
McLean, Putnam, and Woodford	853,941	[e] 1,296,237	[e] 1,447,873	[e] 1,089,417	[e] 1,309,736	− [e] 379,425
Macon and Moultrie	363,987	329,490	396,573	[c] 308,063	347,400	+ 39,347
Macoupin	4,555,834	4,832,540	5,492,216	7,070,146	7,381,165	+ 311,019
Madison	3,546,256	3,419,955	4,173,587	5,364,251	5,074,383	− 289,868
Marion	906,837	925,365	999,109	1,120,426	1,119,206	− 1,220
Marshall	383,331	(e)	(e)	437,087	310,784	− 126,303
Menard	76,603	78,993	159,336	213,478	203,477	− 10,001
Mercer	372,528	340,840	274,692	268,791	287,443	+ 18,652
Montgomery	2,597,677	2,877,459	3,075,712	4,204,722	4,231,122	+ 26,400
Peoria	1,055,323	1,193,351	1,307,900	1,547,916	1,295,460	− 252,456
Perry	2,236,480	2,383,658	2,474,573	2,739,914	2,917,590	+ 177,676
Randolph	956,582	892,948	965,089	1,397,629	1,627,414	+ 229,785
Rock Island	36,022	24,747	33,580	55,062	36,068	− 19,014
St. Clair	3,246,322	2,908,129	4,172,697	6,955,766	7,810,186	+ 854,420
Saline	3,746,656	4,166,249	4,153,516	5,188,777	5,684,594	+ 495,817
Sangamon	5,679,595	5,075,823	5,128,970	8,062,735	8,331,764	+ 269,029
Shelby	196,339	88,672	78,273	132,591	193,346	+ 60,755
Stark	12,703	11,919	8,013	.....	(c)	(c)
Tazewell	335,566	263,247	385,611	508,215	484,681	− 23,534
Vermilion	2,394,081	2,469,263	2,833,909	3,886,480	3,973,478	+ 86,998
Will	136,758	141,416	(e)	(e)	(e)	(e)
Williamson	7,066,029	7,264,395	8,077,627	10,645,697	11,338,562	+ 692,865
Small mines	99,046	100,747	103,587	134,820	73,438	− 61,382
Total value	57,589,197 $64,693,529	58,829,576 $64,622,471	66,195,336 $82,457,954	86,199,387 $162,281,822	89,291,105 $206,860,291	+ 3,091,718 +$44,578,469

[a] No production in Jefferson County.
[b] Gallatin includes Johnson County.
[c] Greene includes McDonough, Moultrie, and Stark counties in 1917 and 1918.
[d] No production in Morgan County, 1916 and 1918; in Morgan and Schuyler counties, 1917.
[e] McLean, etc., includes Marshall County, 1915; Marshall and Will counties in 1916; Will County, 1917; Logan and Will counties in 1918.

INDIANA.

Indiana, with a production of 30,678,000 tons of coal in 1918, made a remarkable new high record. It is no mean performance for a field of the magnitude of Indiana to double its production in six years, but Indiana accomplished the feat. The production of coal in Indiana in 1912 was 15,285,718, less than half that of 1918, only six years later. Knox County alone increased from 1,619,000 tons in 1914 to 3,823,000 tons in 1918, and Clay County more than trebled its production in the same period. The largest producing county, Vigo, more than doubled its output in the period from 1913, when 4,237,274 tons were mined, to 1918, when the production was 8,935,000 tons.

The increase in 1918 was largely made possible by the greater number of men employed. The number of employees increased from 26,528 in 1917 to 30,376 in 1918. The average number of days

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worked increased slightly from 221 in 1917 to 227 days in 1918. The average daily output per employee decreased from 4.52 tons in 1917 to 4.45 tons in 1918.

The weekly operating statistics shown graphically in figure 78 indicate much the same condition in Indiana as in Illinois, lack of cars as the principal cause of nonproduction in the first half of the year and general improvement in the second half until after the armistice, when production declined because of lack of demand.

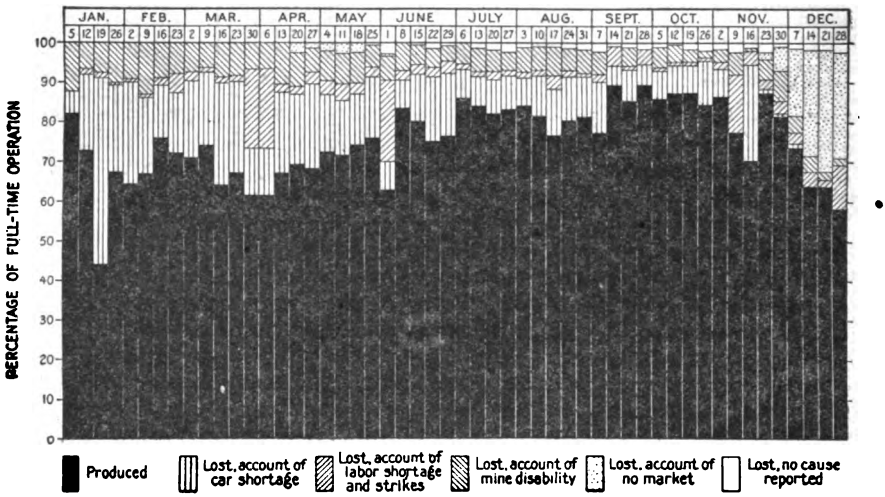

FIGURE 78.—Percentage of full-time operation of coal mines and of losses of running time, by causes and by weeks, in Indiana, in 1918.

Coal produced in Indiana in 1917.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
					Underground.	Surface.	Total.	
Clay	1,055,757	48,180	37,092	1,141,029	969	406	1,375	207
Daviess	110,371	30,970	5,883	147,224	150	49	199	227
Fountain and Warren	15,510	5,400	.....	20,910	29	7	36	221
Gibson	456,739	9,688	5,148	471,575	724	112	836	210
Greene	3,326,494	61,047	110,497	3,498,038	2,748	427	3,175	228
Knox	2,988,945	55,843	75,134	3,119,922	2,313	409	2,722	196
Owen and Perry	53,689	25,426	8,263	87,378	38	64	102	208
Parke	350,690	12,810	23,555	387,055	425	34	459	277
Pike	940,913	22,923	20,138	983,974	1,177	210	1,387	209
Spencer	.....	5,081	.....	5,061	9	.....	9	213
Sullivan	3,367,367	77,908	83,627	3,528,902	2,952	533	3,485	201
Vanderburg	145,495	228,541	10,163	384,199	366	45	411	267
Vermilion	4,112,039	11,903	88,696	4,212,638	3,455	516	3,971	234
Vigo	6,999,545	155,705	148,093	7,303,343	6,502	707	7,209	233
Warrick	1,067,623	75,501	26,262	1,169,386	807	345	1,152	214
Small mines	.....	78,675	.....	78,675	.....	.....	.....	.....
	24,991,177	905,601	642,551	26,539,329	22,664	3,864	26,528	221

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Value of coal produced in Indiana in 1917.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Total value.	Average value per ton.
Clay	$2,381,846	$126,592	$71,739	$2,580,177	$2.62
Daviess	269,080	60,787	10,822	340,689	2.31
Fountain and Warren	39,553	14,875	.....	54,428	2.60
Gibson	1,002,714	22,470	10,138	1,035,322	2.00
Greene	6,665,438	125,444	219,433	7,010,315	2.20
Knox	5,662,032	113,590	112,989	5,888,611	1.89
Owen and Perry	127,648	51,438	19,264	198,350	2.27
Parke	723,221	24,375	42,018	789,614	2.04
Pike	1,687,270	45,888	35,984	1,769,142	1.80
Spencer	.....	8,106	.....	8,106	1.60
Sullivan	6,174,933	168,307	156,753	6,499,993	1.84
Vanderburg	291,592	444,094	18,700	754,386	1.96
Vermilion	7,975,701	27,133	163,658	8,166,492	1.94
Vigo	14,724,821	319,480	266,651	15,310,952	2.10
Warrick	2,196,318	138,160	47,733	2,382,211	2.04
Small mines	.....	151,318	.....	151,318	1.92
	49,922,167	1,842,057	1,175,882	52,940,106	.....
Average value per ton	2.00	2.03	1.83	1.99	1.99

Coal produced in Indiana in 1918.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
					Underground.	Surface.	Total.	
Clay	1,476,983	34,251	61,348	1,572,582	1,090	643	1,733	205
Daviess	170,241	38,448	7,119	215,808	254	58	312	221
Fountain and Warren	10,246	5,034	.....	15,280	15	14	29	212
Gibson	534,168	68,209	7,316	609,693	610	124	734	208
Greene	3,241,378	66,515	118,275	3,426,168	2,306	1,066	3,372	213
Knox	3,689,515	41,566	91,772	3,822,853	2,760	341	3,101	209
Owen and Perry	234,590	11,650	20,280	266,520	42	231	273	190
Parke	297,411	12,445	4,140	313,996	394	46	440	251
Pike	1,103,525	21,297	14,590	1,139,412	1,333	225	1,558	202
Spencer	6,046	2,410	.....	8,456	19	2	21	206
Sullivan	4,136,769	92,056	118,032	4,346,857	3,408	1,519	4,927	213
Vanderberg	118,301	219,727	9,412	347,440	373	46	419	263
Vermilion	4,090,455	10,404	104,949	4,205,808	3,187	578	3,765	252
Vigo	8,578,258	163,146	193,972	8,935,376	7,121	1,161	8,282	246
Warrick	1,273,765	101,910	24,071	1,399,746	1,067	343	1,410	229
Small mines	.....	52,639	.....	52,639	.....	.....	.....	.....
	28,961,651	941,707	775,276	30,678,634	23,979	6,397	30,376	227

Value of coal produced in Indiana in 1918.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Total value.	Average value per ton.
Clay	$3,661,997	$96,331	$134,430	$3,892,758	$2.48
Daviess	400,130	83,729	16,422	500,281	2.32
Fountain and Warren	26,733	14,100	.....	40,833	2.67
Gibson	1,233,887	145,762	16,317	1,395,966	2.29
Greene	7,404,336	158,513	282,945	7,845,794	2.29
Knox	8,443,584	99,486	158,528	8,701,598	2.28
Owen and Perry	728,994	32,393	54,971	816,858	3.06
Parke	713,434	29,812	11,562	754,808	2.40
Pike	2,612,880	46,101	24,150	2,683,131	2.35
Spencer	14,279	8,402	.....	22,681	2.68
Sullivan	9,383,083	223,198	256,553	9,862,834	2.27
Vanderberg	276,611	519,675	17,635	813,921	2.34
Vermilion	9,219,482	23,759	214,037	9,457,278	2.25
Vigo	19,535,324	379,592	391,463	20,306,379	2.27
Warrick	2,920,545	207,675	51,195	3,179,415	2.27
Small mines	.....	110,066	.....	110,066	2.09
	66,575,299	2,179,094	1,630,208	70,384,601	.....
Average value per ton	2.30	2.31	2.10	2.29	2.29

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Coal produced in Indiana, 1914–1918, in net tons.

County.	1914	1915	1916	1917	1918	Increase or decrease, 1918.
Clay	454,009	295,451	629,522	1,141,029	1,572,582	+ 431,553
Daviess	91,608	79,061	78,537	147,224	215,808	+ 68,584
Dubois	[a] 5,400	[a] 3,000	[a] 94,601	.....	.....	.....
Fountain and Warren	40,764	23,800	13,911	20,910	15,280	— 5,630
Gibson	280,636	271,177	333,980	471,575	609,693	+ 138,118
Greene	2,280,085	2,324,634	2,440,311	3,498,038	3,426,168	— 71,870
Knox	1,619,083	2,212,315	2,752,213	3,119,922	3,822,353	+ 702,931
Owen	111,355	91,318	(a)	62,860	[b] 266,520	+ [b] 179,142
Parke	331,845	166,048	281,697	387,055	313,996	— 73,059
Perry	13,800	11,075	(a)	24,500	(b)	(b)
Pike	578,693	646,166	815,304	983,974	1,139,412	+ 155,438
Spencer	8,510	6,695	6,746	5,081	8,456	+ 3,375
Sullivan	2,999,148	2,587,108	2,763,433	3,528,902	4,346,357	+ 817,955
Vanderburg	288,191	227,331	330,135	384,199	347,440	— 36,759
Vermillion	2,135,836	2,734,546	3,420,088	4,212,638	4,205,808	— 6,830
Vigo	4,767,828	4,688,338	5,285,542	7,303,343	8,935,376	+ 1,632,033
Warrick	624,770	577,473	774,116	1,169,386	1,399,746	+ 230,360
Small mines	59,571	59,516	73,392	78,675	52,639	— 26,036
Total value	16,641,132 $18,290,928	17,006,152 $18,637,476	20,093,528 $25,506,246	26,539,329 $32,940,106	30,678,634 $70,384,601	+ 4,139,305 +$17,444,495

[a] Dubois includes Martin County in 1914 and 1915; Owen and Perry in 1916.
[b] Owen includes Perry County.

Coal produced in Indiana, by beds, in 1917 and 1918.[a]

County.	Year.	Vein of coal.							Total.
		Third.	Fourth.	Fifth.	Sixth.	Seventh.	Minshall.	Block.	
Clay	1917	505,457	78,211	139,721	.....	.....	.....	424,285	1,147,674
	1918	859,904	33,735	170,841	.....	.....	.....	444,757	1,509,237
Daviess	1917	3,211	.....	107,002	.....	.....	7,907	.....	118,120
	1918	3,272	.....	162,409	.....	.....	11,712	.....	177,393
Gibson	1917	.....	.....	461,877	.....	.....	.....	.....	461,877
	1918	.....	.....	534,864	.....	.....	.....	.....	534,864
Greene	1917	10,070	2,552,141	799,111	914	.....	.....	.....	3,362,236
	1918	143,275	2,271,300	995,443	170,786	.....	.....	.....	3,580,804
Knox	1917	.....	34,048	2,888,991	52,108	.....	.....	.....	2,975,147
	1918	.....	111,412	3,563,369	125,026	.....	.....	.....	3,799,807
Owen	1917	.....	.....	.....	.....	.....	.....	50,825	50,825
	1918	.....	.....	.....	.....	.....	.....	157,867	157,867
Parke	1917	314,726	.....	.....	.....	.....	.....	51,983	366,709
	1918	231,701	.....	.....	.....	.....	.....	63,170	294,871
Pike	1917	.....	.....	978,672	.....	.....	.....	.....	978,672
	1918	.....	.....	1,132,507	.....	.....	.....	.....	1,132,507
Spencer	1917	.....	.....	.....	.....	.....	.....	.....	.....
	1918	.....	.....	6,165	.....	.....	.....	.....	6,165
Sullivan	1917	.....	826,215	742,529	1,940,596	111,864	.....	.....	3,621,204
	1918	.....	891,153	893,993	2,119,503	261,137	.....	.....	4,165,786
Vanderburg	1917	.....	.....	353,024	.....	.....	.....	.....	353,024
	1918	.....	.....	351,822	.....	.....	.....	.....	351,822
Vermillion	1917	494,862	1,594,092	2,142,341	.....	.....	.....	.....	4,231,295
	1918	356,920	1,519,640	2,506,012	.....	.....	.....	.....	4,382,572
Vigo	1917	85,815	3,264,522	3,489,856	15,784	.....	327,507	107,214	7,290,698
	1918	334,227	4,651,243	3,381,800	20,062	.....	373,185	84,441	8,844,958
Warrick	1917	.....	.....	1,098,786	.....	.....	.....	.....	1,098,786
	1918	.....	.....	1,371,449	.....	.....	.....	.....	1,371,449
	1917	1,414,141	8,349,229	13,201,910	2,009,402	111,864	335,414	634,307	26,056,267
	1918	1,929,299	9,478,483	15,070,674	2,435,377	261,137	384,897	750,235	30,310,102
Increase.	1918	515,158	1,129,254	1,868,764	425,975	149,273	49,483	115,928	4,253,835

[a] Complied by the Indiana Coal Trade Bureau. The figures do not include output of wagon mines.

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IOWA.

The decrease in production of coal in Iowa from 8,965,830 tons in 1917 to 8,192,195 tons in 1918 was largely due to lack of demand in the spring months. Had the opportunity been extended for continuous operation the supply of both labor and transportation was sufficient to have made possible a production greater in 1918 than in 1917. The average number of days worked in 1918 was 245, as compared with 251 in 1917. During the period in the spring of 1918, when demand was so slack that mines were closed down for days and weeks, there was an exodus of mining labor, with the result that the total number of men employed in the year decreased from 14,266 in 1917 to 13,328 in 1918. The decrease in men was largely among the miners and others working underground.

Coal produced in Iowa in 1917.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
					Underground.	Surface.	Total.	
Adams	.....	4,016	.....	4,016	26	7	33	141
Appanoose	1,529,622	85,776	48,056	1,663,454	3,325	401	3,726	243
Boone	181,761	56,103	6,857	244,721	465	57	522	206
Dallas	567,338	8,510	12,629	588,477	832	109	941	258
Greene, Lucas, Warren, and Wayne	734,649	23,027	18,644	776,320	1,063	94	1,157	255
Guthrie and Webster	25,876	3,803	.....	29,679	63	7	70	276
Jasper	280,532	22,715	965	304,212	397	47	444	255
Mahaska	128,478	14,107	3,235	145,820	216	24	240	234
Marion	459,177	21,187	24,635	504,999	748	130	878	211
Monroe	2,331,400	44,365	70,905	2,446,670	2,662	404	3,066	266
Page and Taylor	7,500	10,443	.....	17,943	48	6	54	212
Polk	1,409,684	403,992	32,163	1,845,839	2,363	246	2,609	267
Van Buren	2,207	4,224	.....	6,431	14	2	16	223
Wapello	296,242	41,962	8,305	346,509	450	60	510	248
Small mines [a]	.....	40,740	.....	40,740	.....	.....	.....	.....
	7,954,466	784,970	226,394	8,965,830	12,672	1,594	14,266	251

[a] Includes Jefferson County.

Value of coal produced in Iowa in 1917.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Total value.	Average value per ton.
Adams	.....	$13,285	.....	$13,285	$3.31
Appanoose	$4,035,430	200,336	$82,477	4,318,243	2.60
Boone	580,997	169,669	12,320	762,986	3.12
Dallas	1,381,139	25,062	24,307	1,430,508	2.43
Greene, Lucas, Warren, and Wayne	1,557,482	68,988	34,099	1,660,569	2.14
Guthrie and Webster	68,996	12,330	.....	81,326	2.74
Jasper	549,162	67,728	2,150	619,040	2.03
Mahaska	344,522	31,213	4,743	380,478	2.61
Marion	1,051,980	49,828	46,587	1,148,395	2.27
Monroe	4,872,267	108,634	101,921	5,082,822	2.08
Page and Taylor	26,250	42,200	.....	68,450	3.81
Polk	3,340,616	1,158,759	62,547	4,561,922	2.47
Van Buren	6,360	12,695	.....	19,555	3.04
Wapello	708,245	113,921	22,475	844,641	2.44
Small mines [a]	.....	104,188	.....	104,188	2.56
	18,523,946	2,178,836	393,626	21,096,408	.....
Average value per ton	2.33	2.78	1.74	2.35	2.35

[a] Includes Jefferson County.

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Coal produced in Iowa in 1918.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
					Underground.	Surface.	Total.	
Adams	.....	5,405	13	5,418	26	4	30	237
Appanoose	1,478,943	57,084	23,226	1,559,253	3,082	397	3,479	241
Boone	211,599	58,430	7,590	277,619	453	115	568	238
Dallas	509,543	10,972	6,963	527,478	799	70	869	234
Davis, Greene, Warren, and Wayne	129,959	13,180	3,733	146,872	240	33	273	197
Guthrie and Webster	18,889	11,237	600	30,726	65	9	74	236
Jasper	216,148	22,246	10,557	248,951	359	42	401	227
Lucas	485,292	5,993	12,236	503,521	358	60	418	273
Mahaska	206,775	10,285	4,800	221,860	274	44	318	258
Marion	566,079	26,114	17,073	609,266	875	134	1,009	240
Monroe	2,212,243	34,143	71,543	2,317,929	2,743	347	3,090	258
Page and Taylor	5,645	10,557	.....	16,202	47	5	52	201
Polk	1,153,000	258,464	22,969	1,434,433	2,068	228	2,296	251
Van Buren	6,017	6,928	250	13,195	13	16	29	211
Wapello	198,898	37,212	9,056	245,166	372	50	422	208
Small mines	.....	34,306	.....	34,306	.....	.....	.....	.....
	7,399,030	602,556	190,609	8,192,195	11,774	1,554	13,328	245

Value of coal produced in Iowa in 1918.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Total value.	Average value per ton.
Adams	.....	$19,247	$11	$19,258	$3.55
Appanoose	$4,837,346	183,206	56,162	5,076,714	3.26
Boone	718,360	222,875	17,292	958,527	3.45
Dallas	1,549,048	39,142	18,641	1,606,831	3.05
Davis, Greene, Warren and Wayne	412,988	43,672	6,575	463,235	3.15
Guthrie and Webster	61,833	38,152	1,000	100,985	3.29
Jasper	658,679	70,485	27,882	757,046	3.04
Lucas	1,330,958	23,418	34,261	1,388,637	2.76
Mahaska	589,742	31,510	9,074	630,326	2.84
Marion	1,694,976	70,283	40,887	1,806,146	2.96
Monroe	6,191,328	99,910	154,410	6,445,648	2.78
Page and Taylor	19,193	35,874	.....	55,067	3.40
Polk	3,512,434	935,197	57,096	4,504,727	3.14
Van Buren	18,464	24,159	562	43,185	3.27
Wapello	611,948	108,447	24,272	744,667	3.04
Small mines	.....	102,238	.....	102,238	2.98
	22,207,297	2,047,815	448,125	24,703,237	.....
Average value per ton	3.00	3.40	2.35	3.02	3.02

Coal produced in Iowa in 1914–1918, in net tons.

County.	1914	1915	1916	1917	1918	Increase or decrease, 1918.
Adams	6,660	8,340	11,703	4,016	5,418	+ 1,402
Appanoose	1,272,276	1,225,100	1,227,127	1,663,454	1,559,253	−104,201
Boone	181,952	156,260	170,562	244,721	277,619	+ 32,898
Dallas	466,697	470,881	473,971	568,477	527,478	− 40,999
Greene, Lucas, and Warren	302,132	[a] 597,784	[a] 742,304	[a] 776,320	[a] 650,393	−[a] 125,927
Guthrie	3,925	3,968	[b] 18,800	[b] 29,679	[b] 30,726	+[b] 1,047
Jasper	241,991	268,167	232,825	304,212	248,951	− 55,261
Jefferson and Keokuk	[c] 13,149	[c] 6,710	[c] 7,381	[d]	.....	.....
Mahaska	272,868	245,786	159,395	145,820	221,860	+ 76,040
Marion	311,183	360,155	361,800	504,999	609,266	+104,267
Monroe	2,273,066	2,157,349	1,772,614	2,446,670	2,317,929	−128,741
Page and Taylor	9,902	8,617	10,161	17,943	16,202	− 1,741
Polk	1,706,779	1,744,304	1,719,844	1,845,839	1,434,433	−411,406
Van Buren	(c)	(c)	(c)	6,431	13,195	+ 6,764
Wapello	237,176	313,993	316,332	346,509	245,166	−101,343
Wayne	76,524	(a)	(a)	(a)	(a)	(a)
Webster	33,692	18,905	(b)	(b)	(b)	(b)
Small mines	41,050	27,824	35,961	[d] 40,740	34,306	− 6,434
	7,451,022	7,614,143	7,260,800	8,965,830	8,192,195	−773,635
Total value	$13,364,070	$13,577,608	$13,530,383	$21,096,408	$24,703,237	+$3,606,298

[a] Greene, etc., includes Wayne County in 1915, 1916, 1917 and 1918 and Davis County in 1918.
[b] Guthrie includes Webster County in 1916, 1917 and 1918.
[c] Jefferson, etc., includes Van Buren County.
[d] Small mines include Jefferson County. No production in Keokuk County.

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KANSAS.

A large increase in production of coal in Crawford County and a small increase in Osage County, which together offset decreases in all other counties, gave the Kansas coal fields an increase of 376,972 tons, or 5.2 per cent, in 1918 over 1917. The production in 1918 was 7,561,947 tons, and was the highest recorded for the State, the nearest approach to this figure having been in 1907, when the production was 7,322,000 tons. The increase in production was attained with approximately the same number of men employed, but working a greater number of days, 234 men in 1918 against 216 in 1917.

The weekly reports of operating conditions in Iowa, Missouri, Kansas, Oklahoma, Arkansas, and Texas, comprising what was described as zone 17 by the Fuel Administration, are combined and

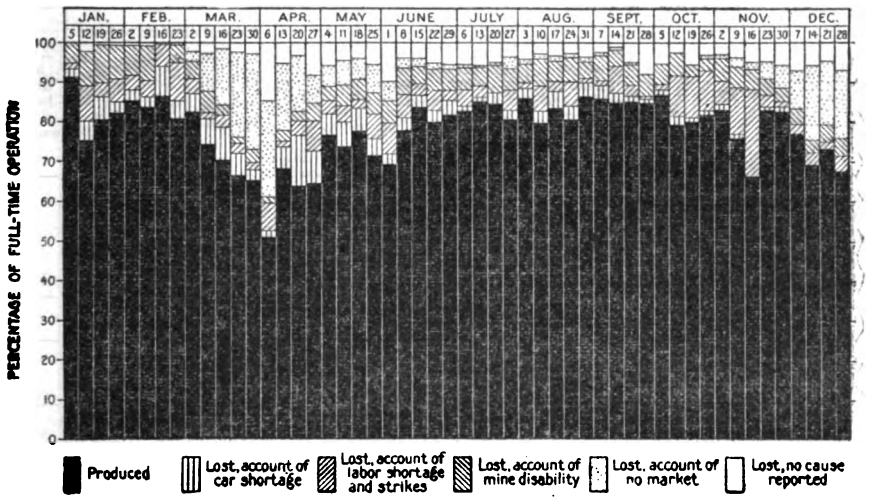

FIGURE 79.—Percentage of full-time operation of coal mines and of losses of running time, by causes and by weeks, in Iowa, Missouri, Kansas, Oklahoma, Arkansas, and Texas, in 1918.

shown graphically in figure 79. In this general field the strength of the market was the factor of greatest importance in determining the rate of production. At no time in 1918 was loss of operating time because of car shortage as great as in the eastern fields.

Coal produced in Kansas in 1917.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
					Underground.	Surface.	Total.	
Cherokee	1,349,607	10,978	35,810	1,396,395	1,236	378	1,614	223
Crawford	5,295,453	74,148	143,955	5,513,556	6,592	1,396	7,988	215
Leavenworth	107,878	45,516	5,315	158,709	457	58	515	278
Linn and Osage	85,569	19,582	384	105,535	531	32	563	157
Small mines	.....	10,780	.....	10,780	.....	.....	.....	.....
	6,838,507	161,004	185,464	7,184,975	8,816	1,864	10,680	216

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Value of coal produced in Kansas in 1917.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Total value.	Average value per ton.
Cherokee	$3,071,624	$39,110	$74,641	$3,185,375	$2.28
Crawford	12,116,085	196,649	254,861	12,566,595	2.28
Leavenworth	311,654	136,394	14,763	462,811	2.92
Linn and Osage	308,586	61,112	737	370,435	3.56
Small mines	.....	33,061	.....	33,061	3.07
	15,807,949	465,326	345,002	16,618,277	.....
Average value per ton	2.31	2.89	1.86	2.31	2.31

Coal produced in Kansas in 1918.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
					Underground.	Surface.	Total.	
Cherokee	1,268,653	9,358	33,219	1,311,230	1,278	472	1,750	289
Crawford	5,732,975	90,492	161,084	5,984,551	6,455	1,432	7,887	239
Leavenworth	87,765	41,231	5,714	134,710	455	63	518	282
Linn	3,760	4,579	100	8,739	36	7	43	139
Osage	95,205	11,276	142	106,623	428	39	467	195
Small mines	.....	16,094	.....	16,094	.....	.....	.....	.....
	7,188,358	173,330	200,259	7,561,947	8,652	2,013	10,665	234

Value of coal produced in Kansas in 1918.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Total value.	Average value per ton.
Cherokee	$3,690,629	$26,257	$82,826	$3,799,712	$2.90
Crawford	16,497,041	238,913	419,342	17,155,296	2.87
Leavenworth	331,840	164,065	20,768	516,673	3.84
Linn	11,805	17,077	200	29,082	3.33
Osage	414,765	49,555	649	464,969	4.36
Small mines	.....	62,410	.....	62,410	3.88
	20,946,080	558,277	523,785	22,028,142	.....
Average value per ton	2.91	3.22	2.62	2.91	2.91

Coal produced in Kansas, 1914–1918, in net tons.

	1914	1915	1916	1917	1918	Increase or decrease, 1918.
Cherokee	1,382,810	1,707,456	1,529,453	1,396,395	1,311,230	− 85,165
Crawford	4,752,114	4,843,232	5,053,239	5,513,556	5,984,551	+ 470,995
Leavenworth	110,791	153,055	149,622	158,709	134,710	− 23,999
Linn	10,480	10,541	8,306	12,492	8,739	− 3,753
Osage	88,371	100,779	125,221	93,043	106,623	+ 13,580
Small mines	[a] 16,422	9,411	15,614	10,780	16,094	+ 5,314
	6,360,988	6,824,474	6,881,455	7,184,975	7,561,947	+ 376,972
Total value	$11,238,253	$11,360,630	$12,252,723	$16,618,277	$22,028,142	+$5,409,865

[a] Includes Franklin County.

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KENTUCKY.

The production of coal in Kentucky in 1918 was 31,612,617 tons, valued at $80,666,842, an increase compared with 1917 of 3,804,646 tons, or 13.7 per cent, in quantity and $20,369,189, or 33.8 per cent, in value. Both eastern and western Kentucky shared in this increase. The production in the eastern part of the State was 20,723,023 tons, valued at $56,179,991, in 1918, a gain compared with 1917 of 3,219,475 tons, or 18.3 per cent, in quantity and $12,793,001, or 29.5 per cent, in value; and the production in the western part of the State was 10,798,690 tons, valued at $24,274,312, an increase over 1917 of 584,210 tons, or 6 per cent, in quantity and $7,536,913, or 45 per cent, in value. It will be recalled that in 1917 the western part of the State recorded much the larger gain over 1916, and it is interesting to note that the production in eastern Kentucky

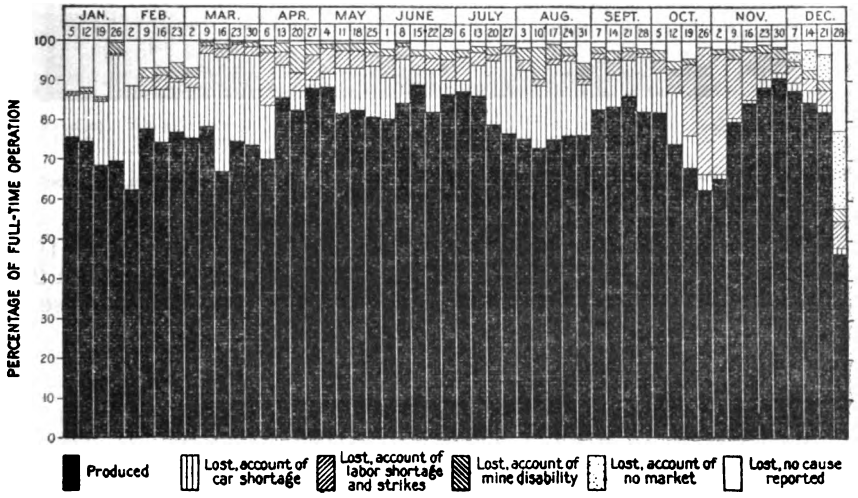

FIGURE 80.—Percentage of full-time operation of coal mines and of losses of running time, by causes and by weeks, in southeastern Kentucky and in Tennessee, in 1918.

in 1918 represented a gain of 18.4 per cent and the production in the western fields a gain of 39 per cent, as compared with 1916.

The increases in 1918 were more or less general, the only counties to record decreases, and those slight, were Johnson, Letcher, and Morgan in the east and Hopkins in the west.

The weekly reports of operating conditions shown graphically in figures 80, 81, and 82 indicate the lowest average percentage of full-time operation in western Kentucky, with car and labor shortage as the principal factors limiting production. In the Hazard and northeastern districts car shortage was largely responsible for nonproduction in the first half of the year, and in October and November labor shortage, resulting from the epidemic of influenza, was the important cause of closing down the mines. The weekly statistics for southeastern Kentucky are combined with Tennessee and shown in figure 80. In this region conditions of car supply and labor were generally better than in the western and northeastern parts of the State.

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In all districts lack of demand or "no market" was a noticeable feature during the last few weeks of 1918.

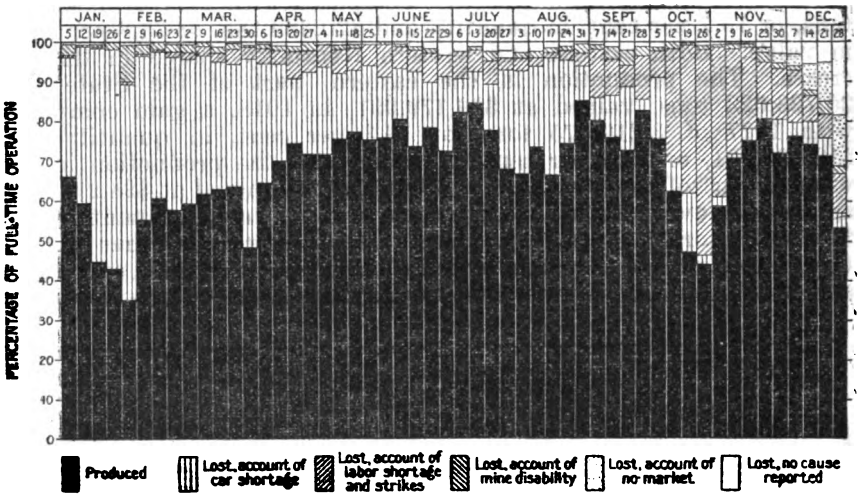

FIGURE 81.—Percentage of full-time operation of coal mines and of losses of running time, by causes and by weeks, in the Hazard and northeastern districts of Kentucky, in 1918.

The average number of days worked increased from 214 in 1917 to 230 in 1918—from 209 to 231 in the eastern districts and from 225 to 228 in the western districts. Likewise there was an increase in

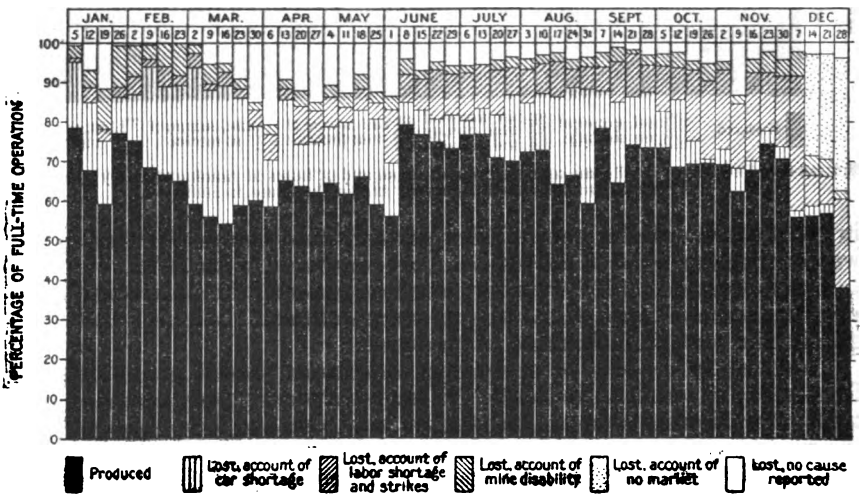

FIGURE 82.—Percentage of full-time operation of coal mines and of losses of running time, by causes and by weeks, in western Kentucky, in 1918.

the number of men employed in both fields—the number in the eastern part of the State increased from 23,503 in 1917 to 26,918 in 1918 and the number in the western field increased from 11,423 to 12,424.

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Coal produced in Kentucky in 1917.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Made into coke at mines (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
						Underground.	Surface.	Total.	
Eastern district:									
Bell	1,986,968	46,502	45,652	.....	2,079,122	2,960	1,023	3,983	196
Boyd	95,963	3,395	2,336	.....	101,714	150	62	212	239
Breathitt	54,117	1,497	267	.....	55,881	104	41	145	106
Carter	119,031	5,857	25,666	.....	150,554	179	66	245	225
Floyd	819,886	7,900	18,077	.....	845,863	943	223	1,166	171
Harlan	1,838,604	31,795	17,620	279,623	2,167,741	2,039	669	2,708	203
Jackson and Pulaski	12,415	6,450	156	.....	19,021	33	22	55	163
Johnson	829,341	9,567	30,894	.....	869,802	1,012	191	1,203	210
Knott, Martin, and Morgan	68,561	938	181	.....	69,680	172	59	231	207
Knox	536,564	7,281	17,190	.....	561,035	873	219	1,092	201
Laurel	79,285	169	749	.....	80,203	188	51	239	144
Lawrence	36,981	1,353	297	.....	38,631	63	52	115	138
Lee	29,519	1,100	378	.....	30,997	65	18	83	176
Letcher	3,398,131	41,415	31,233	.....	3,470,779	2,904	437	3,341	231
McCreary	684,926	3,565	4,442	.....	692,933	1,004	213	1,217	238
Perry	1,627,923	23,327	9,545	.....	1,660,795	1,428	585	2,013	205
Pike	3,477,332	107,231	63,154	198,934	3,846,651	2,878	1,008	3,886	237
Whitley	724,490	10,141	27,515	.....	762,146	1,322	247	1,569	168
	16,420,147	309,483	295,361	478,557	17,503,548	18,317	5,186	23,503	209
Western district:									
Christian	55,071	750	2,100	.....	57,921	122	21	143	240
Daviess	12,337	61,186	1,140	.....	74,663	92	11	103	199
Henderson	205,422	74,536	12,489	.....	292,447	404	63	467	218
Hopkins	2,662,948	147,101	120,893	121,059	3,052,001	2,403	467	2,870	260
McLean	103,078	8,190	1,300	.....	113,468	109	17	126	245
Muhlenberg	3,266,498	67,237	78,081	.....	3,411,816	3,566	452	4,018	204
Ohio	829,019	33,804	32,996	.....	895,819	1,117	168	1,285	190
Union	787,472	75,365	52,521	.....	915,358	873	176	1,049	210
Webster	1,328,406	29,485	43,096	.....	1,400,987	1,159	203	1,362	258
	9,251,151	497,654	344,616	121,059	10,214,480	9,845	1,578	11,423	225
Small mines[a]	3,500	86,443	.....	.....	89,943	.....	.....	.....	.....
Grand total	25,674,798	893,580	639,977	599,616	27,807,971	28,162	6,764	34,926	214

[a] Includes Hancock County.

Value of coal produced in Kentucky in 1917.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Made into coke at mines.	Total value.	Average value per ton.
Eastern district:						
Bell	$5,183,507	$117,306	$105,552	.....	$5,406,365	$2.60
Boyd	228,163	6,388	4,530	.....	239,081	2.35
Breathitt	137,042	3,435	646	.....	141,123	2.53
Carter	248,980	8,870	51,516	.....	309,366	2.05
Floyd	2,244,517	17,437	36,178	.....	2,298,132	2.72
Harlan	4,704,506	58,868	42,569	$810,907	5,616,845	2.59
Jackson and Pulaski	33,070	10,076	273	.....	43,419	2.28
Johnson	2,820,871	28,685	90,823	.....	2,940,379	3.38
Knott, Martin, and Morgan	213,588	2,283	363	.....	216,234	3.10
Knox	1,264,091	16,556	35,144	.....	1,315,791	2.35
Laurel	182,529	399	1,719	.....	184,647	2.30
Lawrence	94,662	1,896	400	.....	96,958	2.51
Lee	78,713	2,752	742	.....	82,207	2.65
Letcher	7,523,226	82,580	60,472	.....	7,666,258	2.21
McCreary	1,790,884	7,661	10,791	.....	1,809,336	2.61
Perry	4,553,987	47,849	18,482	.....	4,620,318	2.78
Pike	7,920,194	215,163	99,392	231,212	8,465,961	2.20
Whitley	1,867,507	17,917	49,146	.....	1,934,570	2.54
	41,090,037	646,096	608,738	1,042,119	43,386,990	.....
Average value per ton	2.50	2.09	2.06	2.18	2.48	2.48

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Value of coal produced in Kentucky in 1917—Continued.

County.	Loaded at mines for Shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Made into coke at mines.	Total value.	Average value per ton.
Western district:						
Christian	$123,537	$1,590	$4,000	.....	$129,127	$2.23
Daviess	21,590	125,036	2,133	.....	148,759	1.99
Henderson	377,868	161,871	18,531	.....	558,270	1.91
Hopkins	3,937,236	215,340	126,897	$67,564	4,347,037	1.42
McLean	196,897	16,122	2,454	.....	215,473	1.90
Muhlenberg	5,928,045	113,587	136,342	.....	6,177,974	1.81
Ohio	1,268,756	46,799	32,498	.....	1,348,053	1.50
Union	1,370,316	129,621	90,796	.....	1,590,733	1.74
Webster	2,113,595	47,223	61,155	.....	2,221,973	1.59
	15,337,840	857,189	474,806	67,564	16,737,399	.....
Average value per ton	1.66	1.72	1.38	.56	1.64	1.64
Small mines [a]	8,960	164,304	.....	.....	173,264	1.93
Grand total	56,436,837	1,667,589	1,083,544	1,109,683	60,297,653	.....
Average value per ton	2.20	1.87	1.69	1.85	2.17	2.17

[a] Includes Hancock County.

Coal produced in Kentucky in 1918.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Made into coke at mines (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
						Underground.	Surface.	Total.	
Eastern district:									
Bell	2,362,010	34,244	51,621	.....	2,447,875	2,928	982	3,910	229
Boyd	104,656	2,898	3,090	.....	110,644	173	53	226	252
Breathitt	174,893	3,063	1,180	.....	179,136	271	69	340	171
Carter	141,721	43,841	2,215	.....	187,777	213	86	299	216
Clay	3,700	.....	40	.....	3,740	13	4	17	85
Floyd	1,291,939	15,500	19,517	.....	1,326,956	1,589	620	2,209	212
Harlan	2,825,940	55,443	38,907	281,443	3,201,733	2,588	1,535	4,123	244
Jackson, Martin, and Pulaski	53,085	2,350	656	.....	56,091	99	35	134	233
Johnson	748,343	10,772	32,126	.....	791,241	773	185	958	213
Knox	636,806	15,803	16,828	.....	669,437	898	270	1,168	204
Laurel	115,476	13,251	300	.....	129,027	269	63	332	117
Lawrence	44,466	1,400	1,200	.....	47,066	50	21	71	184
Lee	47,320	10,151	234	.....	57,705	89	29	118	174
Letcher	3,207,060	35,226	37,429	.....	3,279,715	2,625	459	3,084	243
McCreary	716,678	13,962	4,254	.....	734,894	1,022	225	1,247	249
Morgan	54,423	6,128	2,781	.....	63,332	130	70	200	251
Perry	2,100,941	11,316	7,966	.....	2,120,223	1,816	621	2,437	221
Pike	4,171,968	66,199	67,929	167,346	4,473,442	3,141	1,250	4,391	245
Whitley	783,743	30,634	28,612	.....	842,989	1,270	384	1,654	220
	19,585,168	372,181	316,885	448,789	20,723,023	19,957	6,961	26,918	231
Western district:									
Butler and Christian	76,441	1,213	7,605	.....	85,259	125	19	144	200
Daviess	55,302	30,330	920	.....	86,552	89	19	108	208
Hancock	5,500	6,780	.....	.....	12,280	19	4	23	206
Henderson	303,139	73,578	17,345	.....	394,062	396	63	459	236
Hopkins	2,601,082	173,160	124,635	83,500	2,987,377	2,567	722	3,289	244
McLean	141,979	8,969	3,928	.....	154,871	143	26	169	240
Muhlenberg	3,450,167	125,716	74,590	.....	3,650,473	3,509	539	4,048	216
Ohio	889,686	27,703	34,440	.....	951,829	1,076	168	1,244	206
Union	854,575	85,761	52,637	.....	992,973	882	185	1,067	235
Webster	1,387,902	48,690	45,110	1,312	1,483,014	1,560	313	1,873	239
	9,765,773	586,900	361,205	84,812	10,798,690	10,366	2,058	12,424	228
Small mines	.....	90,904	.....	.....	90,904	.....	.....	.....	.....
Grand total	29,350,941	1,049,985	678,090	533,601	31,612,617	30,323	9,019	39,342	230

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Value of coal produced in Kentucky in 1918.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Made into coke at mines.	Total value.	Average value per ton.
Eastern district:						
Bell	$6,878,849	$93,970	$122,085	.....	$7,094,904	$2.90
Boyd	266,620	6,317	6,142	.....	279,079	2.52
Breathitt	509,559	8,448	3,440	.....	521,447	2.91
Carter	369,784	90,386	4,289	.....	464,459	2.47
Clay	10,650	.....	75	.....	10,725	2.87
Floyd	3,887,472	34,408	51,292	.....	3,973,172	2.99
Harlan	7,244,824	142,085	88,658	$773,969	8,249,536	2.58
Jackson, Martin, and Pulaski	157,400	6,660	1,805	.....	165,865	2.96
Johnson	2,315,592	27,291	87,690	.....	2,430,573	3.07
Knox	1,834,290	43,232	35,992	.....	1,913,514	2.86
Laurel	328,259	39,753	600	.....	368,612	2.86
Lawrence	129,092	1,800	2,400	.....	133,292	2.83
Lee	132,311	30,315	630	.....	163,256	2.83
Letcher	7,954,500	76,756	86,821	.....	8,118,077	2.48
McCreary	2,047,928	35,626	7,135	.....	2,090,689	2.84
Morgan	238,183	15,683	3,175	.....	257,041	4.06
Perry	5,455,940	17,238	18,610	.....	5,491,788	2.59
Pike	11,062,678	145,843	127,018	682,842	12,018,381	2.69
Whitley	2,282,763	86,834	65,984	.....	2,435,581	2.89
	53,106,694	902,645	713,841	1,456,811	56,179,991	2.71
Average value per ton	2.71	2.43	2.25	3.25	2.71	.....
Western district:						
Butler and Christian	186,719	3,065	20,449	.....	210,233	2.47
Daviess	119,758	69,764	2,082	.....	191,554	2.21
Hancock	13,375	14,201	.....	.....	27,576	2.25
Henderson	713,338	206,279	35,496	.....	955,613	2.42
Hopkins	5,796,336	408,196	211,824	83,500	6,502,356	2.18
McLean	326,547	21,114	7,129	.....	352,790	2.28
Muhlenberg	8,058,374	287,790	139,542	.....	8,485,706	2.32
Ohio	1,942,320	53,089	55,529	.....	2,050,938	2.15
Union	1,927,414	192,687	93,298	.....	2,213,394	2.23
Webster	3,091,977	108,822	82,041	1,312	3,284,152	2.21
	22,177,158	1,365,007	647,335	84,812	24,274,312	.....
Average value per ton	2.27	2.33	1.79	1.00	2.25	2.25
Small mines	.....	212,539	.....	.....	212,539	2.34
Grand total	75,283,852	2,480,191	1,361,176	1,541,623	80,666,842	.....
Average value per ton	2.56	2.36	2.01	2.89	2.55	2.55

Coal produced in Kentucky, 1915–1918, in net tons.

County.	1915	1916	1917	1918	Increase or decrease, 1918.
Eastern district:					
Bell	2,306,831	2,244,542	2,079,122	2,447,875	+ 368,753
Boyd	78,000	86,581	101,714	110,644	+ 8,930
Breathitt	[a] 74,592	[a] 37,212	55,881	179,136	+ 123,255
Carter	83,413	123,577	150,554	187,777	+ 37,223
Clay	.....	.....	.....	3,740	+ 3,740
Floyd	545,074	873,453	845,863	1,326,956	+ 481,093
Greenup	(a)	(a)	.....	.....	.....
Harlan	1,726,798	2,214,228	2,167,741	3,201,733	+ 1,033,992
Johnson	975,464	975,486	869,802	791,241	− 78,561
Knox	767,713	803,524	561,035	669,437	+ 108,402
Laurel	85,136	87,638	80,203	129,027	+ 48,824
Lawrence	(a)	(a)	38,681	47,066	+ 8,385
Lee	(a)	(a)	30,997	57,705	+ 26,708
Letcher	2,239,334	3,671,436	3,470,779	3,279,715	− 191,064
McCreary	569,535	665,290	692,933	734,894	+ 41,961
Morgan	58,815	48,727	[b] 69,680	63,332	− 6,348
Perry	547,962	902,262	1,060,795	2,120,223	+ 459,428
Pike	2,830,239	3,756,927	3,846,651	4,473,442	+ 626,791
Whitley	805,446	905,428	762,146	842,989	+ 80,843
Other counties	[c] 5,418	[c] 10,164	[c] 19,021	[c] 56,091	+ [c] 37,070
	13,689,770	17,495,475	17,503,548	20,723,023	+ 3,219,475

[a] Breathitt County included Greenup, Knott, Lawrence, and Lee in 1915 and 1916.
[b] Includes Knott and Martin counties.
[c] Jackson and Pulaski in 1915, 1916, and 1917; Jackson, Martin, and Pulaski in 1918.

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Coal produced in Kentucky, 1915–1918, in net tons—Continued.

County.	1915	1916	1917	1918	Increase or decrease, 1918.
Western district:					
Christian	[a] 93,256	107,975	57,921	[a] 85,259	+ [a] 27,338
Daviess	42,778	59,855	74,663	86,552	+ 11,889
Hancock	4,000	(b)	(b)	12,280	+ 12,280
Henderson	166,704	185,748	292,447	394,062	+ 101,615
Hopkins	2,332,143	2,622,525	3,052,001	2,987,377	− 64,624
McLean	(a)	58,380	113,468	154,871	+ 41,403
Muhlenberg	2,232,045	2,086,819	3,411,816	3,650,473	+ 238,657
Ohio	519,820	494,940	895,819	951,829	+ 56,010
Union	742,110	660,076	915,358	992,973	+ 77,615
Webster	1,409,000	1,570,238	1,400,987	1,483,014	+ 82,027
	7,541,856	7,786,556	10,214,480	10,798,690	+ 584,210
Small mines	130,048	[b] 111,966	[b] 89,943	90,904	+ 961
Grand total	21,361,674	25,393,997	27,807,971	31,612,617	+ 3,804,646
Total value	$21,491,008	$30,193,047	$30,297,653	$30,666,842	+$20,369,189

[a] Christian and McLean counties combined in 1915; Christian and Butler in 1918.
[b] Hancock County included in small mines.

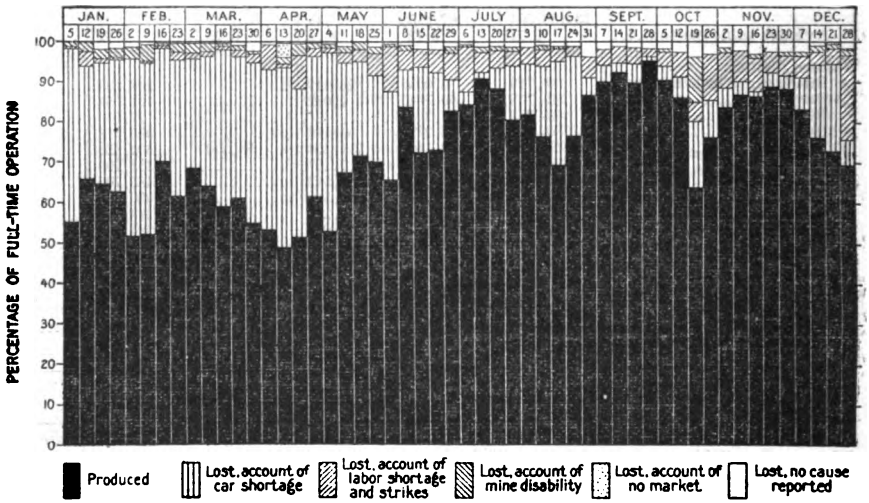

FIGURE 83.—Percentage of full-time operation of coal mines and of losses of running time, by causes and by weeks, in the Cumberland-Piedmont district, Md.–W. Va., and the Somerset district, Pa., in 1918.

MARYLAND.

The production of coal in Maryland in 1918 was 4,497,297 net tons, valued at $12,466,189, a decrease, compared with 1917, of 248,627 tons, or 5.2 per cent, in quantity but an increase of $798,337, or 6.8 per cent, in value. As compared with 1917 the average number of days worked increased slightly, from 254 to 261, and the number of men employed decreased from 5,919 in 1917 to 5,568 in 1918; the decrease in output is to be attributed to a comparative shortage of labor. With the labor that was available, however, more coal could have been produced had the mines been able to operate more days in the year. According to the reports of the operators, compiled weekly by the Geological Survey and the Fuel Administration, the operation of the mines was seriously interfered with in the early

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part of the year by shortage of cars. These data for Maryland are shown graphically in figure 83, combined with the reports from the Somerset field of Pennsylvania, with which Maryland was combined in the organization of the Fuel Administration.

Coal produced in Maryland in 1917.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
					Underground.	Surface.	Total.	
Allegany	3,602,013	70,200	55,396	3,727,609	3,807	987	4,794	260
Garrett	960,423	3,960	3,514	992,867	889	236	1,125	227
Small mines	.....	25,448	.....	25,448	.....	.....	.....	.....
	4,583,436	104,578	58,910	4,745,924	4,696	1,223	5,919	254

Value of coal produced in Maryland in 1917.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Total value.	Average value per ton.
Allegany	$8,999,653	$152,803	$134,353	$9,286,809	$2.49
Garrett	2,316,235	10,356	6,668	2,333,259	2.35
Small mines	.....	47,784	.....	47,784	1.88
	11,315,888	210,943	141,021	11,667,852	.....
Average value per ton	2.47	2.02	2.39	2.46	2.46

Coal produced in Maryland in 1918.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
					Underground.	Surface.	Total.	
Allegany	3,382,099	61,361	46,866	3,490,326	3,519	932	4,451	266
Garrett	961,194	13,143	8,880	983,192	858	259	1,117	240
Small mines	.....	23,779	.....	23,779	.....	.....	.....	.....
	4,343,293	98,283	55,716	4,497,297	4,377	1,191	5,568	261

Value of coal produced in Maryland in 1918.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Total value.	Average value per ton.
Allegany	$9,397,754	$168,991	$130,700	$9,697,445	$2.78
Garrett	2,653,144	29,509	23,032	2,705,685	2.75
Small mines	.....	63,059	.....	63,059	2.65
	12,050,898	261,559	153,732	12,466,189	.....
Average value per ton	2.77	2.66	2.76	2.77	2.77

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Coal produced in Maryland, 1914–1918, in net tons.

County.	1914	1915	1916	1917	1918	Increase or decrease, 1918.
Allegheny	3,449,365	3,388,365	3,454,454	3,727,609	3,490,326	— 237,283
Garrett	671,621	782,976	994,694	992,867	983,192	— 9,675
Small mines	12,561	9,136	10,898	25,448	23,779	— 1,669
	4,133,547	4,180,477	4,460,046	4,745,924	4,497,297	— 248,627
Total value	$5,234,796	$5,330,845	$6,947,623	$11,667,852	$12,466,189	+$798,337

MICHIGAN.

The production of coal in Michigan in 1918 was 1,464,818 tons, valued at $5,615,097, an increase, compared with 1917, of 90,013 tons, or 6.5 per cent, in quantity and $1,188,783, or 29.9 per cent in value. There was a decrease of 49,000 tons in Bay County, but increases elsewhere in the State. The average number of days worked decreased from 254 in 1917 to 237 in 1918 but the number of men employed increased from 2,406 to 2,558. The average annual output per man increased slightly, from 571 tons to 573 tons, despite the fewer days worked, and the average daily output gained notably, 2.42 tons in 1918 against 2.25 in 1917.

Coal produced in Michigan in 1917.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
					Underground.	Surface.	Total.	
Bay	666,306	12,956	8,775	688,037	993	85	1,078	277
Saginaw	517,427	58,403	22,650	598,480	936	107	1,043	248
Other counties[a]	61,062	9,458	16,540	87,060	225	60	285	189
Small mines	.....	1,228	.....	1,228	.....	.....	.....	.....
	1,244,795	82,045	47,965	1,374,805	2,154	252	2,406	254

[a] Calhoun, Genesee, Shiawassee, and Tuscola.

Value of coal produced in Michigan in 1917.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Total value.	Average value per ton.
Bay	$2,052,883	$51,659	$26,325	$2,130,867	$3.10
Saginaw	1,689,364	235,644	64,528	1,989,536	3.32
Other counties[a]	197,857	48,600	52,741	299,198	3.44
Small mines	.....	6,713	.....	6,713	5.47
	3,940,104	342,616	143,594	4,426,314	.....
Average value per ton	3.17	4.18	2.99	3.22	3.22

[a] Calhoun, Genesee, Shiawassee, and Tuscola.

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Coal produced in Michigan in 1918.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
					Underground.	Surface.	Total.	
Bay	580,613	38,850	19,225	638,688	920	129	1,049	256
Saginaw	623,390	30,677	37,743	691,810	1,041	168	1,209	218
Other counties [a]	76,655	28,639	28,238	133,532	246	54	300	247
Small mines	.....	788	.....	788	.....	.....	.....	.....
	1,280,658	98,954	85,206	1,464,818	2,207	351	2,558	237

[a] Calhoun, Genesee, Shiawassee, and Tuscola.

Value of coal produced in Michigan in 1918.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Total value.	Average value per ton.
Bay	$2,168,323	$147,913	$57,981	$2,374,217	$3.72
Saginaw	2,409,812	134,971	121,825	2,666,608	3.85
Other counties [a]	321,208	155,046	94,338	570,592	4.27
Small mines	.....	3,680	.....	3,680	4.67
	4,899,343	441,610	274,144	5,615,097	.....
Average value per ton	3.83	4.46	3.22	3.83	3.83

[a] Calhoun, Genesee, Shiawassee, and Tuscola.

Coal produced in Michigan, 1914–1918, in net tons.

County.	1914	1915	1916	1917	1918	Increase or decrease 1918.
Bay	617,415	551,772	549,307	688,037	638,688	− 49,349
Saginaw	584,648	539,036	560,559	598,480	691,810	+ 93,330
Tuscola	[a] 80,866	[a] 64,650	[a] 70,179	[a] 87,060	[a] 133,532	+ [a]46,472
Small mines	101	660	315	1,228	788	− 440
	1,283,030	1,156,128	1,180,360	1,374,805	1,464,818	+ 90,013
Total value	$2,559,796	$2,372,797	$2,653,182	$4,426,314	$5,615,097	+$1,188,783

[a] Tuscola County included Genesee and Ingham in 1914; Ingham in 1915 and 1916; Calhoun, Genesee and Shiawassee in 1917 and 1918.

MISSOURI.

There was little change in the quantity of coal produced in Missouri in 1918, as compared with 1917. The production in 1918 was 5,667,730 tons, a decrease of 2,819 tons. Increases in Adair, Barton, Lafayette and a few other of the more important producing counties were offset by decreases in Macon, Randolph, Ray, and other counties. That the production in 1918 did not fall further below that in 1917 was due to the increase in the average daily output per man from 2.44 tons in 1917 to 2.51 tons in 1918. The average number of men employed decreased somewhat, from 9,668 to 9,590, and the number of days worked from 240 to 235. In the western

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fields car shortage was at no time in 1918 a serious cause of nonproduction and throughout the year the percentage of full-time operation attained was largely determined by the demand and by the willingness of labor to work when the demand was good.

Coal produced in Missouri in 1917.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
					Underground.	Surface.	Total.	
Adair	674,785	9,999	8,300	693,084	1,056	66	1,122	239
Audrain	1,039	10,673	23	11,735	54	4	58	222
Barton	976,088	13,118	67,087	1,056,291	86	1,018	1,104	188
Bates	73,545	13,160	3,127	89,832	143	74	217	167
Boone	4,172	12,138	100	16,410	52	7	59	241
Callaway	41,031	17,502	2,348	60,881	99	44	143	217
Clay, Dade, Johnson, and Platte	161,993	30,025	3,203	195,221	350	56	406	265
Cooper and Moniteau	4,125	450	.....	4,575	12	2	14	171
Grundy, Harrison, and Sullivan	63,279	19,217	9,589	92,085	128	29	157	277
Henry	83,090	24,164	3,303	110,557	176	82	258	167
Lafayette	895,342	39,356	27,041	961,739	2,027	243	2,270	243
Linn	97,638	28,144	2,730	128,512	326	42	368	258
Macon	894,376	20,598	9,693	924,667	1,123	110	1,233	269
Putnam	18,433	2,756	462	21,651	110	24	134	113
Randolph	435,806	157,149	5,290	598,245	736	56	792	275
Ray	465,368	44,449	6,468	516,285	1,171	78	1,249	257
Other counties[a]	52,581	1,777	3,017	57,375	31	53	84	217
Small mines	.....	131,404	.....	131,404	.....	.....	.....	.....
	4,942,689	576,079	151,781	5,670,549	7,680	1,988	9,668	240

[a] Ralls and Vernon.

Value of coal produced in Missouri in 1917.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Total value.	Average value per ton.
Adair	$1,487,639	$33,287	$14,150	$1,535,076	$2.21
Audrain	2,877	30,801	69	33,747	2.88
Barton	2,465,477	26,089	161,495	2,653,061	2.51
Bates	173,442	34,245	8,391	216,078	2.41
Boone	13,727	34,423	350	48,500	2.96
Callaway	112,203	57,281	5,989	175,473	2.88
Clay, Dade, Johnson, and Platte	439,209	89,284	7,197	535,690	2.74
Cooper and Moniteau	18,066	2,250	.....	20,316	4.44
Grundy, Harrison, and Sullivan	154,015	56,965	17,508	228,488	2.48
Henry	223,831	68,020	9,330	301,181	2.72
Lafayette	2,347,258	120,725	54,949	2,522,932	2.62
Linn	264,063	80,266	5,277	349,626	2.72
Macon	1,861,680	52,445	15,663	1,929,788	2.09
Putnam	41,774	6,833	597	49,204	2.27
Randolph	920,864	360,511	9,421	1,290,796	2.16
Ray	1,241,905	119,994	16,964	1,378,863	2.64
Other counties[a]	128,610	4,163	7,110	139,883	2.44
Small mines	.....	347,162	.....	347,162	2.64
	11,896,660	1,524,744	334,460	13,755,864	.....
Average value per ton	2.41	2.65	2.20	2.43	2.43

[a] Ralls and Vernon.

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Coal produced in Missouri in 1918.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
					Underground.	Surface.	Total.	
Adair	720,824	19,752	15,028	755,604	1,239	117	1,356	240
Audrain	260	11,327	160	11,747	32	5	37	262
Barton	1,067,381	21,309	57,353	1,146,043	230	860	1,090	185
Bates	97,150	5,761	2,167	105,078	215	95	310	138
Boone	1,402	14,277	450	16,129	50	7	57	239
Caldwell, Clay, and Platte	79,151	12,512	2,427	94,090	277	51	328	211
Callaway	22,142	23,673	2,824	48,139	80	40	120	241
Cooper and Moniteau	2,850	1,443	.....	4,302	14	.....	14	140
Dade	3,951	1,376	.....	5,327	15	.....	15	195
Grundy, Harrison, and Sullivan	52,634	17,736	9,629	79,999	113	23	136	258
Henry	55,080	21,871	2,339	79,290	123	60	183	182
Johnson	144,758	4,326	1,760	150,844	142	18	160	238
Lafayette	929,960	44,289	35,305	1,009,554	1,926	211	2,137	258
Linn	114,021	32,887	1,358	148,266	282	34	316	270
Macon	781,303	20,336	11,038	812,677	1,003	88	1,091	255
Putnam	40,582	3,959	1,008	45,549	128	17	145	202
Randolph	428,232	26,406	6,949	463,587	809	65	874	232
Ray	456,150	29,964	7,866	493,980	916	139	1,055	249
Vernon	44,062	1,519	.....	45,581	7	49	56	174
Other counties [a]	77,089	1,544	5,062	84,315	43	67	110	234
Small mines	.....	67,629	.....	67,629	.....	.....	.....	.....
	5,119,591	385,896	162,243	5,667,730	7,644	1,946	9,590	235

[a] Franklin, Ralls, and St. Clair.

Value of coal produced in Missouri in 1918.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Total value.	Average value per ton.
Adair	$1,936,556	$62,047	$39,940	$2,038,543	$2.70
Audrain	790	42,154	520	43,464	3.70
Barton	3,119,942	73,737	161,217	3,354,896	2.93
Bates	302,531	16,889	5,536	324,956	3.09
Boone	5,258	55,480	1,687	62,425	3.87
Caldwell, Clay, and Platte	297,287	46,714	8,709	352,710	3.75
Callaway	73,764	94,468	7,315	175,547	3.65
Cooper and Moniteau	16,265	7,088	.....	23,353	5.43
Dade	13,860	4,472	.....	18,332	3.44
Grundy, Harrison, and Sullivan	173,134	69,156	26,481	268,771	3.36
Henry	149,125	65,028	6,950	221,103	2.79
Johnson	426,000	14,049	5,008	445,057	2.95
Lafayette	2,959,650	149,910	81,876	3,191,436	3.16
Linn	409,632	115,379	4,694	529,705	3.57
Macon	2,135,559	65,562	28,516	2,229,637	2.74
Putnam	109,205	13,808	2,220	125,233	2.75
Randolph	1,268,826	87,639	17,808	1,374,273	2.96
Ray	1,602,828	98,826	22,790	1,724,444	3.49
Vernon	127,213	4,783	.....	131,996	2.90
Other counties [a]	239,246	5,176	12,350	256,772	3.05
Small mines	.....	233,845	.....	233,845	3.46
	15,366,671	1,326,210	433,617	17,126,498	.....
Average value per ton	3.00	3.44	2.67	3.02	3.02

[a] Franklin, Ralls, and St. Clair.

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Coal produced in Missouri, 1914–1918, in net tons.

County.	1914	1915	1916	1917	1918	Increase or decrease 1918.
Adair	256,397	280,187	436,413	693,084	755,604	+ 62,520
Audrain	10,360	13,803	6,985	11,735	11,747	+ 12
Barton	505,282	657,069	935,624	1,056,291	1,146,043	+ 89,752
Bates	145,031	71,312	83,534	89,832	105,078	+ 15,246
Boone	12,514	17,450	18,556	16,410	16,129	− 281
Caldwell, Clay, Dade, Johnson, and Platte	110,559	88,964	[a] 102,430	[a] 195,221	250,261	+ 55,040
Callaway	39,555	64,136	61,814	60,881	48,139	− 12,742
Cole, Cooper, and Moniteau	[b] 3,032	[b] 3,350	([b] [d] [g])	[b] 4,575	[b] 4,302	− [b] 273
Grundy, Harrison, Schuyler, and Sullivan	114,949	[c] 103,881	[c] 89,511	[c] 92,085	[c] 79,999	− [c] 12,086
Henry	224,894	183,311	171,933	110,557	79,290	− 31,267
Howard, Montgomery, and Ralls	[e] 23,900	([f] [g])	([g] [h])	([f] [g])	([f] [g])	([f] [g])
Lafayette	703,029	799,297	907,116	961,739	1,009,554	+ 47,815
Linn	108,626	97,242	108,338	128,512	148,266	+ 19,754
Macon	765,365	666,245	795,631	924,667	812,677	− 111,990
Putnam	10,367	([g])	8,519	21,651	45,549	+ 23,898
Randolph	424,245	379,262	368,563	598,245	463,587	− 134,658
Ray	324,080	205,184	412,975	516,285	493,980	− 22,305
Vernon	43,165	75,377	81,844	([g])	([g])	([g])
Other counties	.....	[g] 15,103	[g] 15,513	[g] 57,375	[g] 129,896	+ 72,521
Small mines	110,630	90,420	136,847	131,404	67,629	− [g] 63,775
Total value	3,935,980 $6,802,325	3,811,593 $6,595,918	4,742,146 $9,044,505	5,670,549 $13,755,864	5,667,730 $17,126,498	− 2,819 +$3,370,634

[a] No production in Caldwell County.
[b] No production in Cole County.
[c] No production in Schuyler County.
[d] No production in Moniteau County.
[e] No production in Montgomery County.
[f] No production in Howard and Montgomery counties.
[g] Other counties include Livingston, Putnam, and Ralls in 1915; Cooper, Livingston, Montgomery, and Ralls in 1916; Ralls and Vernon, and increase in Cooper and Moniteau in 1917 and Franklin, Ralls, St. Clair, and Vernon in 1918.
[h] No production in Howard County.

MONTANA.

The increase in production of coal in Montana in 1918 of 305,816 tons came mainly from Cascade and Musselshell counties (the Great Falls and Roundup fields). The Red Lodge field, in Carbon County, had a decrease of 142,565 tons, or 8 per cent. The total production in 1918 was 4,532,505 tons, valued at $11,444,875, and it set a new high record for the State. Compared with 4,149 men who worked an average of 268 days in 1917, 4,559 men worked an average of 264 days in 1918.

Coal produced in Montana in 1917.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
					Underground.	Surface.	Total.	
Carbon	1,637,203	55,945	97,122	1,790,270	1,511	350	1,861	282
Cascade	987,781	22,994	14,132	1,024,907	852	173	1,025	275
Musselshell	988,180	18,441	47,400	1,054,021	744	206	950	229
Sheridan	5,368	7,586	.....	12,954	12	.....	12	237
Other counties [a]	264,387	33,236	9,050	306,673	219	82	301	274
Small mines	.....	37,864	.....	37,864	.....	.....	.....	.....
	3,882,919	176,066	167,704	4,226,689	3,338	811	4,149	268

[a] Blaine, Chouteau, Fergus, Hill, Missoula, Richland, and Valley.

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Value of coal produced in Montana in 1917.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Total value.	Average value per ton.
Carbon	$3,788,360	$138,685	$116,478	$4,043,523	$2.26
Cascade	1,969,370	52,543	27,362	2,049,275	2.00
Musselshell	1,960,163	63,870	72,889	2,096,922	1.99
Sheridan	11,166	15,356	.....	26,522	2.05
Other counties [a]	496,378	88,744	16,924	602,046	1.96
Small mines	.....	100,848	.....	100,848	2.66
	8,225,437	460,046	233,653	8,919,136	.....
Average value per ton	2.12	2.61	1.39	2.11	2.11

[a] Blaine, Chouteau, Fergus, Hill, Missoula, Richland, and Valley.

Coal produced in Montana in 1918.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked
					Underground	Surface.	Total.	
Carbon	1,504,113	50,172	93,420	1,647,705	1,387	347	1,734	267
Cascade	1,210,457	44,078	18,381	1,272,916	960	226	1,186	277
Hill	.....	9,165	.....	9,165	15	5	20	187
Musselshell	1,153,068	18,968	51,035	1,223,091	566	490	1,056	258
Sheridan	6,503	9,209	100	15,812	19	6	25	187
Other counties [a]	303,753	31,202	12,506	347,551	400	138	538	243
Small mines [b]	.....	16,265	.....	16,265	.....	.....	.....	.....
	4,177,894	179,079	175,532	4,532,505	3,347	1,212	4,559	264

[a] Blaine, Chouteau, Fergus, Phillips, Richland, and Stillwater.
[b] Includes Toole County.

Value of coal produced in Montana in 1918.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Total value.	Average value per ton.
Carbon	$4,048,889	$140,632	$89,542	$4,279,063	$2.60
Cascade	3,042,138	102,505	50,844	3,195,487	2.51
Hill	.....	29,652	.....	29,652	3.24
Musselshell	2,646,067	69,953	106,430	2,822,450	2.31
Sheridan	16,361	21,531	250	38,142	2.41
Other counties [a]	900,888	98,912	30,096	1,029,896	2.96
Small mines [b]	.....	50,185	.....	50,185	3.09
	10,654,343	513,370	277,162	11,444,875	.....
Average value per ton	2.55	2.87	1.58	2.53	2.53

[a] Blaine, Chouteau, Fergus, Phillips, Richland, and Stillwater.
[b] Includes Toole County.

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Coal produced in Montana, 1914–1918, in net tons.

County.	1914	1915	1916	1917	1918	Increase or decrease, 1918.
Carbon	1,212,941	1,172,721	1,534,267	1,790,270	1,647,705	−142,565
Cascade	664,423	619,745	773,113	1,024,907	1,272,916	+248,009
Chouteau	.....	(a)	(a)	(a)	(a)	(a)
Fergus	23,104	68,362	232,681	265,705	(a)	(a)
Hill	16,256	14,117	14,600	6,574	9,165	+2,591
Musselshell	850,040	887,021	1,042,007	1,054,021	1,223,091	+169,070
Sheridan	(a)	6,556	6,073	12,954	15,812	+2,858
Other counties	a30,183	a3,626	a15,560	a34,394	a347,551	+a47,452
Small mines	8,226	17,607	14,226	37,864	b16,265	−b21,599
Total value	2,805,173	2,789,755	3,632,527	4,226,689	4,532,505	+305,816
	$4,913,191	$4,526,509	$6,286,197	$8,919,136	$11,444,875	+$2,525,739

aOther counties include Blaine, Missoula, Park, and Sheridan in 1914; Chouteau, Missoula, and Valley in 1915; Blaine, Chouteau, Missoula, Park, and Valley in 1916; Blaine, Chouteau, Missoula, Richland, and Valley in 1917; and Blaine, Chouteau, Fergus, Phillips, Richland, and Stillwater in 1918.
bIncludes Toole County.

NEW MEXICO.

A decrease in production in 1918 compared with 1917 in the Raton field (Colfax County) of 85,000 tons and an increase in the Gallup field (McKinley County) of 105,000 tons, together with small gains and losses in the several small fields, netted the State an increase of 22,712 tons, or 0.6 per cent. The value of the coal produced in New Mexico in 1918 was $10,787,000, a gain of $3,332,000, or 44.7 per cent, compared with 1917. The average number of days worked declined from 321 in 1917 to 301 in 1918; the number of employees decreased from 4,126 to 4,095; but the average output per man per day gained 3.26 tons in 1918, as compared with 3.02 tons in 1917.

Coal produced in New Mexico in 1917.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Made into coke at mines (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
						Underground.	Surface.	Total.	
Colfax	2,102,815	16,073	4,228	991,488	3,114,604	2,268	578	2,846	336
Lincoln, Santa Fe, and Socorro	181,890	18,616	7,786	.....	208,292	349	188	537	298
McKinley	634,849	6,314	24,135	.....	665,298	552	165	717	286
Rio Arriba and San Juan	8,400	2,075	300	.....	10,775	22	4	26	227
Small mines	.....	1,558	.....	.....	1,558	.....	.....	.....	.....
	2,927,954	44,636	36,449	991,488	4,000,527	3,191	935	4,126	321

Value of coal produced in New Mexico in 1917.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Made into coke at mines.	Total value.	Average value per ton.
Colfax	$3,892,677	$25,452	$5,804	$1,365,481	$5,289,414	$1.70
Lincoln, Santa Fe and Socorro	666,078	60,708	21,268	.....	748,054	3.59
McKinley	1,344,963	10,794	38,420	.....	1,394,177	2.10
Rio Arriba and San Juan	16,800	3,329	483	.....	20,612	1.91
Small mines	.....	2,909	.....	.....	2,909	1.87
	5,920,518	103,192	65,975	1,365,481	7,455,166	.....
Average value per ton	2.02	2.31	1.81	1.38	1.86	1.86

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Coal produced in New Mexico in 1918.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Made into coke at mines (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
						Underground.	Surface.	Total.	
Colfax	1,895,517	20,952	4,660	1,108,092	3,029,221	1,927	635	2,562	308
Lincoln, Santa Fe, and Socorro	191,910	7,295	8,329	.....	207,534	332	139	471	282
McKinley	738,090	6,536	25,917	.....	770,543	691	347	1,038	298
Rio Arriba and San Juan	11,284	2,225	365	.....	13,874	21	3	24	221
Small mines	.....	2,067	.....	.....	2,067	.....	.....	.....	.....
	2,836,801	39,075	39,271	1,108,092	4,023,239	2,971	1,124	4,095	301

Value of coal produced in New Mexico in 1918.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Made into coke at mines.	Total value.	Average value per ton.
Colfax	$5,304,967	$41,968	$8,218	$1,894,091	$7,249,234	$2.39
Lincoln, Santa Fe, and Socorro	901,045	25,215	41,095	.....	967,355	4.66
McKinley	2,445,996	19,625	64,561	.....	2,530,182	3.28
Rio Arriba and San Juan	29,570	6,019	639	.....	36,228	2.61
Small mines	.....	4,063	.....	.....	4,063	1.96
	8,681,568	96,910	114,513	1,894,091	10,787,062	.....
Average value per ton	3.06	2.48	2.92	1.71	2.68	2.68

Coal produced in New Mexico, 1914–1918, in net tons.

County.	1914	1915	1916	1917	1918	Increase or decrease, 1918.
Colfax	3,015,368	2,866,442	2,837,613	3,114,604	3,029,221	− 85,383
Lincoln, Santa Fe, and Socorro	[a] 145,574	157,206	208,617	208,292	207,534	− 758
McKinley	706,731	785,490	735,600	665,298	770,543	+ 105,245
Rio Arriba and San Juan	7,775	8,285	9,285	10,775	13,874	+ 3,099
Small mines	2,246	517	1,896	1,558	2,067	+ 509
	3,877,689	3,817,940	3,793,011	4,000,527	4,023,239	+ 22,712
Total value	$6,230,871	$5,481,361	$5,580,369	$7,455,166	$10,787,082	+$3,331,916

[a] Santa Fe and Socorro counties only.

NORTH DAKOTA.

The production of lignite in North Dakota in 1918 was 719,733 net tons, valued at $1,629,668, a decrease of 70,815 tons, or 9.0 per cent, in quantity and an increase of $203,918, or 14.3 per cent, in value.

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Lignite produced in North Dakota in 1917.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
					Underground.	Surface.	Total.	
Burke	20,000	4,351	.....	24,351	17	21	38	231
Burleigh and Mercer	243,089	11,709	11,847	266,595	189	42	231	273
Divide	98,553	4,164	6,126	108,843	86	37	123	270
Hettinger	2,000	3,710	.....	5,710	8	.....	8	183
McLean	18,151	9,798	200	28,149	29	13	42	281
Morton	.....	24,464	184	24,648	23	1	24	249
Ward	63,931	21,302	3,143	88,376	106	48	154	253
Williams	7,101	32,337	8,945	48,383	36	7	43	265
Other counties[a]	111,796	16,692	3,632	132,120	125	33	158	222
Small mines	.....	68,373	.....	68,373	.....	.....	.....	.....
	559,571	196,900	34,077	790,548	619	202	821	255

[a] Adams, Billings, Bowman, Dunn, Oliver, and Stark.

Value of lignite produced in North Dakota in 1917.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Total value.	Average value per ton.
Burke	$32,730	$9,800	.....	$42,530	$1.75
Burleigh and Mercer	402,934	19,582	$17,060	439,576	1.65
Divide	180,904	10,189	7,801	198,894	1.83
Hettinger	3,200	6,934	.....	10,134	1.77
McLean	30,322	18,298	150	48,770	2.11
Morton	.....	33,302	240	33,542	1.36
Ward	152,712	55,202	3,143	211,057	2.39
Williams	14,169	62,163	12,881	89,213	1.84
Other counties[a]	188,926	29,986	5,282	224,194	1.70
Small mines	.....	127,840	.....	127,840	1.87
	1,005,897	373,296	46,557	1,425,750	.....
Average value per ton	1.80	1.90	1.37	1.80	1.80

[a] Adams, Billings, Bowman, Dunn, Oliver, and Stark.

Lignite produced in North Dakota in 1918.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
					Underground.	Surface.	Total.	
Burke	14,259	4,734	.....	18,993	12	27	39	166
Burleigh and Mercer	283,473	14,035	9,958	307,466	216	76	292	265
Divide	66,874	3,930	5,118	75,922	72	23	95	242
Hettinger	1,000	2,840	.....	3,840	5	.....	5	190
McLean	9,004	9,658	1,350	20,012	12	8	20	234
Morton	60	28,380	60	28,500	28	9	37	205
Ward	71,771	19,341	85	91,197	136	42	178	205
Williams	13,399	36,918	.....	50,317	43	11	54	234
Other counties[a]	66,206	13,103	3,372	82,681	78	30	108	192
Small mines	.....	40,805	.....	40,805	.....	.....	.....	.....
	526,046	173,744	19,943	719,733	602	226	828	220

[a] Adams, Billings, Bowman, Dunn, Oliver, and Stark.

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Value of lignite produced in North Dakota in 1918.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Total value.	Average value per ton.
Burke	$42,026	$10,662	.....	$52,688	$2.77
Burleigh and Mercer	577,725	33,051	$10,900	621,676	2.02
Divide	188,950	9,634	5,323	203,916	2.69
Hettinger	2,000	5,670	.....	7,670	2.00
McLean	20,384	17,454	1,850	39,688	1.98
Morton	120	66,884	105	67,109	2.35
Ward	196,484	49,992	234	245,710	2.69
Williams	36,699	92,502	.....	129,201	2.57
Other counties[a]	154,968	22,289	5,544	182,801	2.21
Small mines	.....	79,209	.....	79,209	1.94
	1,218,365	387,347	23,956	1,629,668	.....
Average value per ton	2.32	2.23	1.20	2.26	2.26

[a] Adams, Billings, Bowman, Dunn, Oliver, and Stark.

Lignite produced in North Dakota, 1914–1918, in net tons.

County.	1914	1915	1916	1917	1918	Increase or decrease, 1918.
Adams	11,062	10,627	11,749	(a)	(a)	(a)
Burke	11,750	10,000	23,400	24,351	18,993	− 5,358
Burleigh	(a)	(a)	[b] 232,561	[b] 289,744	[b] 327,478	+ [b] 37,734
Divide	(a)	(a)	67,871	108,843	75,922	− 32,921
Hettinger	5,100	4,182	(a)	5,710	3,840	− 1,870
McLean	10,161	9,695	(b)	(b)	(b)	(b)
Morton	34,323	50,024	34,871	24,648	28,500	+ 3,852
Stark	(a)	(a)	(a)	(a)	(a)	(a)
Ward	68,157	61,506	74,382	88,376	91,197	+ 2,821
Williams	38,750	32,970	43,093	48,383	50,317	+ 1,934
Other counties	[a] 298,469	[a] 316,422	[a] 98,069	[a] 132,120	[a] 82,681	− 49,439
Small mines	28,913	32,652	48,916	68,373	40,805	− 27,568
Total value	506,685	528,078	634,912	790,548	719,733	− 70,815
	$771,379	$766,072	$946,062	$1,425,750	$1,629,668	+$203,918

[a] Other counties include; Billings, Bowman, Burleigh, Divide, Oliver, and Stark in 1914; Billings, Bowman, Burleigh, Divide, Dunn, Oliver, and Stark in 1915; Billings, Bowman, Dunn, Hettinger, and Stark in 1916; and Adams, Billings, Bowman, Dunn, Oliver, and Stark counties in 1917 and in 1918.
[b] Burleigh County includes McLean and Mercer counties.

OHIO.

The production of coal in Ohio in 1918 was 45,812,943 tons, valued at $118,095,518, an increase as compared with 1917, of 5,064,209 tons, or 12.4 per cent, in quantity and of $17,198,370, or 17 per cent, in value. The increase was general. Of the counties for which separate statistics are presented, only four—Holmes, Jackson, Mahoning, and Wayne—recorded decreases, and of these counties Jackson, the only one of importance, had a very slight decrease. There was no lack of market for coal from Ohio in 1917 or in 1918 until the end of the year, and the increase was the result of more days worked and more men employed. The number of men employed increased from 45,509 in 1917 to 48,450 in 1918, and the average days worked from 210 to 223. As might be inferred from the fact that the increase in number of men employed was largely in those working on the surface, the average output per man per day declined—from 4.26 tons

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to 4.24 tons, but the average annual output increased from 895 tons to 946 tons.

Although the area in which coal from Ohio was permitted to move under the zone system was closely drawn through the summer of 1918, in order to force a large quantity into the Lake trade, the production was in no wise limited on that score. Weekly reports of operating time furnished the Geological Survey and the Fuel Administration by the operators show that in the first half of the year lack of cars was the principal cause limiting production and that until November car shortage was an important factor in the situation.

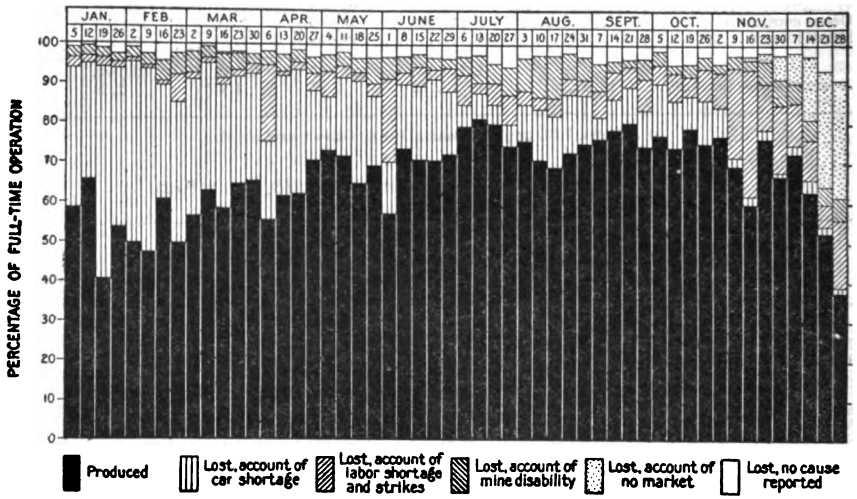

FIGURE 84.—Percentage of full-time operation of coal mines and of losses of running time, by causes and by weeks, in Ohio, in 1918.

After the armistice, from the middle of November to the end of the year, lack of demand for coal from Ohio became increasingly important as a cause of nonproduction. Under the exigencies of the war program the markets in Ohio, Michigan, and Indiana, that normally consume Ohio coal, were largely supplied with coal from Illinois and Indiana during the summer months, so that with the end of the Lake season Ohio operators were not able to dispose of their product in these normal fall and winter markets, and many were obliged in the winter of 1918–19 to curtail production. These data of operating conditions are shown graphically in figure 84.

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Coal produced in Ohio in 1917.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Made into coke at mines (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
						Underground.	Surface.	Total.	
Athens	6,004,615	35,819	115,794	.....	6,156,228	5,882	831	6,713	220
Belmont	10,481,835	557,644	127,025	.....	11,166,504	9,811	1,372	11,183	212
Carroll	356,600	62,364	13,863	.....	432,827	559	61	620	228
Columbiana	489,592	63,630	13,095	.....	566,317	672	101	773	235
Coshocton	244,222	50,432	6,498	.....	301,152	428	85	513	201
Gallia, Morgan, and Scioto	327,121	3,119	9,258	.....	339,498	360	49	409	201
Guernsey	3,794,783	86,586	98,483	.....	3,949,852	3,781	420	4,201	180
Harrison	1,190,574	11,542	14,137	.....	1,216,253	810	492	1,302	184
Hocking	1,888,879	37,116	28,086	.....	1,954,081	1,921	389	2,310	219
Holmes	.....	14,630	6	.....	14,636	20	.....	20	207
Jackson	716,856	108,122	38,864	.....	863,842	1,311	208	1,519	220
Jefferson	5,135,736	356,279	105,075	630	5,597,720	3,972	1,282	5,254	216
Lawrence	148,068	65,939	1,747	.....	215,754	342	75	417	244
Mahoning	5,233	36,775	20	.....	42,028	66	7	75	247
Medina	.....	10,083	5	.....	10,088	19	1	20	206
Meigs	1,110,573	45,814	15,449	.....	1,171,836	1,427	260	1,687	211
Muskingum	372,773	97,113	6,926	.....	476,812	538	113	651	213
Noble	887,458	9,867	15,571	.....	912,896	855	62	917	207
Perry	2,271,373	60,334	44,377	.....	2,376,084	2,744	552	3,296	205
Portage and Summit	82,727	25,653	9,450	.....	117,830	148	43	191	223
Stark	200,370	160,974	11,878	.....	373,222	489	98	587	213
Tuscarawas	1,474,281	225,050	48,466	.....	1,747,797	1,961	366	2,327	208
Vinton	164,052	12,541	19,736	.....	196,329	283	39	322	219
Wayne	114,758	1,968	7,472	.....	124,098	168	34	202	159
Small mines	.....	425,050	.....	.....	425,050	.....	.....	.....	.....
	37,462,479	2,534,344	751,281	630	40,748,734	38,569	6,940	45,509	210

Value of coal produced in Ohio in 1917.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Made into coke at mines.	Total value.	Average value per ton.
Athens	$13,965,388	$67,369	$186,952	.....	$14,219,709	$2.31
Belmont	25,291,823	955,018	253,585	.....	26,500,426	2.37
Carroll	857,435	137,349	34,778	.....	1,029,562	2.38
Columbiana	1,310,734	172,672	34,044	.....	1,517,450	2.66
Coshocton	653,256	119,671	10,435	.....	783,362	2.60
Gallia, Morgan, and Scioto	738,754	2,184	7,669	.....	748,607	2.21
Guernsey	9,180,258	123,285	220,238	.....	9,523,781	2.41
Harrison	3,113,975	24,757	30,402	.....	3,169,134	2.61
Hocking	5,009,855	77,268	50,153	.....	5,137,276	2.63
Holmes	.....	27,643	.....	.....	27,643	1.89
Jackson	1,995,249	209,469	98,906	.....	2,303,626	2.67
Jefferson	13,657,531	777,475	219,553	$1,200	14,655,759	2.62
Lawrence	353,440	140,824	4,413	.....	498,677	2.31
Mahoning	15,699	101,626	30	.....	117,355	2.79
Medina	.....	40,358	20	.....	40,378	4.00
Meigs	3,231,463	135,473	40,612	.....	3,427,548	2.92
Muskingum	821,997	193,866	17,561	.....	1,033,424	2.17
Noble	2,321,080	24,622	40,047	.....	2,385,749	2.61
Perry	5,424,681	108,400	85,539	.....	5,618,620	2.36
Portage and Summit	314,570	70,854	15,159	.....	400,583	3.40
Stark	707,775	449,739	23,264	.....	1,180,778	3.16
Tuscarawas	4,174,772	529,214	134,803	.....	4,838,789	2.77
Vinton	450,425	33,126	40,411	.....	523,962	2.67
Wayne	279,937	6,209	13,259	.....	299,405	2.41
Small mines	.....	915,245	.....	.....	915,245	2.15
	93,890,397	5,443,716	1,561,835	1,200	100,897,148	.....
Average value per ton	2.51	2.15	2.08	1.90	2.48	2.48

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Coal produced in Ohio in 1918.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
					Underground.	Surface.	Total.	
Athens	6,448,602	53,120	127,752	6,629,564	6,671	1,002	7,673	217
Belmont	11,321,360	336,726	194,422	11,852,508	9,545	1,619	11,164	228
Carroll	387,186	49,041	14,797	451,024	554	83	637	228
Columbiana	597,782	57,548	17,941	673,271	686	181	867	252
Coshocton	307,298	42,005	2,569	351,872	458	125	583	218
Gallia and Morgan	384,715	2,126	8,603	395,444	370	46	416	232
Guernsey	4,168,617	38,586	91,609	4,298,812	3,726	456	4,182	219
Harrison	2,007,799	18,363	44,252	2,070,414	949	775	1,724	239
Hocking	2,008,765	48,567	26,596	2,083,928	1,977	373	2,350	217
Holmes	.....	3,400	.....	3,400	6	.....	6	242
Jackson	712,503	76,631	47,576	836,710	1,167	302	1,469	210
Jefferson	6,166,925	394,731	128,280	6,689,936	4,151	1,338	5,489	244
Lawrence	214,317	56,820	2,010	273,147	372	83	455	242
Mahoning	3,328	30,393	730	34,451	58	10	68	237
Medina	.....	7,343	10	7,353	18	1	19	292
Meigs	1,225,653	54,542	18,849	1,299,044	1,464	296	1,760	229
Muskingum	533,907	35,046	4,883	573,836	607	152	759	208
Noble	959,907	7,659	18,623	986,189	776	57	833	237
Perry	3,011,349	45,717	59,366	3,116,432	3,041	764	3,805	197
Portage	119,972	12,282	8,049	140,303	176	42	218	272
Stark	348,247	166,920	18,724	533,891	614	151	765	230
Summit	29,700	48,318	3,160	81,178	89	12	101	226
Tuscarawas	1,684,040	197,950	57,938	1,939,928	1,982	581	2,563	217
Vinton	225,777	2,941	10,405	239,123	343	96	439	215
Wayne	20,771	3,443	1,469	25,683	83	22	105	97
Small mines	.....	225,802	.....	225,802	.....	.....	.....	.....
	42,888,610	2,015,720	908,613	45,812,943	39,883	8,567	48,450	223

Value of coal produced in Ohio in 1918.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Total value.	Average value per ton.
Athens	$16,599,696	$105,166	$266,435	$16,971,297	$2.56
Belmont	28,135,981	688,181	450,895	29,275,057	2.47
Carroll	1,033,748	135,972	38,765	1,208,485	2.68
Columbiana	1,804,542	205,383	44,857	2,054,782	3.05
Coshocton	870,416	109,719	5,976	986,111	2.80
Gallia and Morgan	1,009,712	4,662	15,105	1,029,479	2.60
Guernsey	10,556,309	94,712	207,519	10,858,540	2.53
Harrison	4,916,785	42,919	87,508	5,047,212	2.44
Hocking	5,008,004	102,748	101,739	5,212,491	2.50
Holmes	.....	7,441	.....	7,441	2.19
Jackson	2,354,461	214,061	107,787	2,676,309	3.20
Jefferson	15,779,541	855,490	280,891	16,915,922	2.53
Lawrence	629,328	167,950	5,783	803,061	2.94
Mahoning	14,408	104,257	2,214	120,879	3.51
Medina	.....	31,386	45	31,431	4.27
Meigs	3,382,766	145,082	46,979	3,574,827	2.75
Muskingum	1,353,697	77,922	12,526	1,444,145	2.52
Noble	2,565,511	18,546	48,680	2,632,737	2.67
Perry	7,843,766	111,651	125,004	8,080,421	2.59
Portage	425,650	50,561	14,955	491,166	3.50
Stark	1,202,817	503,529	64,132	1,770,478	3.32
Summit	89,100	130,645	9,417	229,162	2.82
Tuscarawas	4,706,329	479,930	143,277	5,329,536	2.75
Vinton	704,988	8,373	28,985	742,346	3.10
Wayne	76,460	11,645	5,169	93,274	3.63
Small mines	.....	508,929	.....	508,929	2.25
	111,064,015	4,916,860	2,114,643	118,095,518	.....
Average value per ton	2.59	2.44	2.33	2.58	2.58

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Coal produced in Ohio, 1914–1918, in net tons.

County.	1914	1915	1916	1917	1918	Increase or decrease, 1918.
Athens	3,298,189	2,520,488	3,711,931	6,156,228	6,629,564	+ 473,336
Belmont	2,849,181	4,304,566	10,330,941	11,166,504	11,852,508	+ 686,004
Carroll	235,480	344,966	301,137	432,827	451,024	+ 18,197
Columbiana	342,266	541,862	589,527	566,317	673,271	+ 106,954
Coshocton	153,046	198,434	298,298	301,152	351,872	+ 50,720
Gallia, Morgan, and Scioto	207,924	109,380	289,028	339,498	[a] 395,444	+ [a] 55,946
Guernsey	2,936,707	3,232,961	4,386,161	3,949,852	4,298,812	+ 348,960
Harrison	184,892	214,630	973,628	1,216,253	2,070,414	+ 854,161
Hocking	1,231,340	1,264,529	1,401,453	1,954,081	2,083,928	+ 129,847
Holmes	8,934	6,117	5,180	14,636	3,400	− 11,236
Jackson	532,831	565,309	694,100	863,842	836,710	− 27,132
Jefferson	2,172,881	3,608,453	5,532,929	5,597,720	6,689,936	+ 1,092,216
Lawrence	160,077	127,373	179,497	215,754	273,147	+ 57,393
Mahoning	15,903	12,556	19,073	42,028	34,451	− 7,577
Medina, Portage, and Summit	125,063	115,124	116,903	127,918	228,834	+ 100,916
Meigs	534,784	943,889	1,006,935	1,171,836	1,299,044	+ 127,208
Muskingum	328,329	396,986	376,286	476,812	573,836	+ 97,024
Noble	501,942	596,796	857,527	912,896	986,189	+ 73,293
Perry	1,186,674	1,136,476	1,334,759	2,376,084	3,116,432	+ 740,348
Stark	457,933	352,020	296,381	373,222	533,591	+ 160,369
Tuscarawas	921,236	1,367,535	1,504,496	1,747,797	1,939,928	+ 192,131
Vinton	84,372	103,804	104,867	196,329	239,123	+ 42,794
Wayne	88,345	74,649	137,649	124,098	25,683	− 98,415
Small mines	284,686	305,798	312,533	425,050	225,802	− 199,248
	18,843,115	22,434,691	34,728,219	40,748,734	45,812,943	+ 5,064,209
Total value	$21,250,642	$24,207,075	$46,150,907	$100,897,148	$118,096,518	+$17,198,370

[a] No production in Scioto County.

OKLAHOMA.

The increase in production of coal in Oklahoma in 1918 of 426,603 tons, or 9.7 per cent, was generally shared by all the local districts in the State contributing to the total, Coal County alone recording a decrease. The production in Oklahoma in 1918 was 4,813,447 tons, a new high record for the State, the highest output previously attained having been 4,386,844 tons in 1917. The increase in 1918 was attained by approximately the same number of men working a greater number of days—228 days in 1918 compared with 211 in 1917.

Coal produced in Oklahoma in 1917.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
					Underground.	Surface.	Total.	
Coal	545,422	7,221	29,127	581,770	1,173	138	1,311	202
Latimer	796,472	8,782	36,008	841,262	1,014	335	1,349	224
Le Flore	266,830	2,066	16,343	285,239	489	128	617	189
Okmulgee	1,031,030	3,265	17,453	1,051,748	1,809	305	2,114	211
Pittsburg	1,184,377	8,269	86,417	1,279,063	2,223	422	2,645	214
Tulsa	68,937	4,200	.....	73,137	100	16	116	234
Other counties [a]	259,094	3,168	3,842	266,104	209	134	343	215
Small mines [b]	.....	8,521	.....	8,521	.....	.....	.....	.....
	4,152,162	45,492	189,190	4,386,844	7,017	1,478	8,495	211

[a] Atoka, Haskell, Rogers, and Wagoner. [b] Includes Craig County.

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Value of coal produced in Oklahoma in 1917.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Total value.	Average value per ton.
Coal	$1,481,767	$21,303	$71,187	$1,574,257	$2.71
Latimer	2,307,173	25,366	95,037	2,427,576	2.89
Le Flore	664,997	5,704	34,855	705,556	2.47
Okmulgee	2,763,567	10,832	36,368	2,810,767	2.67
Pittsburg	3,675,766	31,062	197,505	3,904,333	3.05
Tulsa	203,299	10,400	.....	213,699	2.92
Other counties [a]	658,216	10,672	6,156	675,044	2.54
Small mines [b]	.....	24,181	.....	24,181	2.84
	11,754,785	139,520	441,108	12,335,413	.....
Average value per ton	2.83	3.07	2.33	2.81	2.81

[a] Atoka, Haskell, Rogers, and Wagoner. [b] Includes Craig County.

Coal produced in Oklahoma in 1918.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
					Underground.	Surface.	Total.	
Coal	503,397	6,584	32,273	542,254	1,064	130	1,194	217
Latimer	865,432	4,690	49,365	919,487	1,145	217	1,362	252
Le Flore	303,657	2,502	25,215	331,374	557	111	668	213
Okmulgee	1,259,465	3,672	19,002	1,282,139	1,739	297	2,036	222
Pittsburg	1,277,918	8,454	77,835	1,364,207	2,209	428	2,637	230
Other counties [a]	358,061	5,397	4,227	367,685	343	211	554	224
Small mines	.....	6,301	.....	6,301	.....	.....	.....	.....
	4,567,930	37,600	207,917	4,813,447	7,057	1,394	8,451	228

[a] Atoka, Haskell, Rogers, Tulsa, and Wagoner.

Value of coal produced in Oklahoma in 1918.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Total value.	Average value per ton.
Coal	$1,866,139	$25,098	$104,690	$1,995,927	$3.68
Latimer	3,207,956	19,159	186,302	3,413,417	3.71
Le Flore	1,050,749	8,699	81,211	1,140,659	3.44
Okmulgee	4,129,866	12,229	57,232	4,199,327	3.28
Pittsburg	5,099,083	34,351	281,415	5,414,849	3.97
Other counties [a]	1,282,892	24,550	11,894	1,319,336	3.59
Small mines	.....	25,369	.....	25,369	4.08
	16,636,685	149,455	722,744	17,508,884	.....
Average value per ton	3.64	3.97	3.48	3.64	3.64

[a] Atoka, Haskell, Rogers, Tulsa, and Wagoner.

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Coal produced in Oklahoma, 1914–1918, in net tons.

County.	1914	1915	1916	1917	1918	Increase or decrease, 1918.
Atoka and Haskell	.....	.....	82,752	230,174	246,049	+ 15,875
Coal	676,292	556,479	524,954	581,770	542,254	− 39,516
Haskell and Latimer	666,274	740,869	810,504	841,262	919,487	+ 78,225
Le Flore	264,023	256,642	266,162	285,239	331,374	+ 46,135
Okmulgee	905,128	869,244	852,206	1,051,748	1,282,139	+ 230,391
Pittsburg	1,373,771	1,132,272	977,043	1,279,063	1,364,207	+ 85,144
Rogers and Wagoner	29,568	20,943	30,817	35,930	[a] 121,636	+ 12,569
Tulsa	68,792	96,160	59,730	73,137	(a)	(a)
Small mines	4,765	[b] 20,971	3,843	[c] 8,521	6,301	− 2,220
Total value	3,988,613 $8,204,015	3,693,580 $7,435,906	3,608,011 $7,525,427	4,336,844 $12,335,413	4,813,447 $17,508,884	+426,603 +$5,173,471

[a] Rogers, etc., includes Tulsa County. [b] Includes Atoka County. [c] Includes Craig County.

OREGON.

The production of coal in Oregon, which comes almost entirely from the Coos Bay field, has been decreasing for years. The lowest recorded output for the State since 1880 was the record for 1918 of 13,328 tons.

Coal produced in Oregon, 1914–1918.

Year.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Total quantity (net tons).	Total value.	Average value per ton.	Number of employees.	Average number of days worked.
1914	37,152	5,798	8,608	51,558	$143,556	$2.78	190	266
1915	30,142	2,272	6,817	39,231	111,240	2.84	151	206
1916	28,373	7,482	6,737	42,592	113,976	2.68	106	236
1917	13,736	9,087	5,504	28,327	95,668	3.38	104	251
1918	4,112	3,946	5,270	13,328	37,454	2.81	40	292

PENNSYLVANIA

ANTHRACITE.

PRODUCTION.

The production of Pennsylvania anthracite in 1918 was 88,237,575 gross tons, valued at $336,480,347, a decrease, compared with 1917, of 701,542 tons, or 0.8 per cent, in quantity, but an increase of $52,829,624, or 18.6 per cent, in value. The output in 1918 was second only to that in 1917 in the history of the anthracite industry.

The demand for anthracite was unusually strong throughout the year. Early in 1918 the Fuel Administration announced that the available production in the 12-month period beginning April 1, 1918, the coal year 1918–19, would be allotted on the basis of the distribution in the coal year 1916–17, with the exception that anthracite would be denied to many sections of the country, such as the West and South, that had received comparatively small shipments in the past and to certain other sections of the country nearer the anthracite mines that had ample local supplies of bituminous coal for domestic use. In general this scheme of allotment was closely followed from April through December, 1918, for the demand for anthracite did

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not slacken, as did that for bituminous, with the signing of the armistice. It was not until the middle of January, 1919, that domestic consumers were satisfied with the supplies of anthracite on hand and, because of the mildness of the winter, ceased to order more coal. A full description of the program of the Fuel Administration with respect to anthracite and the statistics of allotments and deliveries will be found in Part I of the report of the distribution division of the Fuel Administration.

In both the Lehigh and Schuylkill regions production was greater in 1918 than in 1917, but the Wyoming region and Sullivan County recorded decreases. There was a decrease of 2,056,566 tons in the quantity of freshly mined coal, but a substantial increase, 1,254,794 tons, or 20.1 per cent, in the output of washeries, and of 100,230 tons, or 65.8 per cent, in dredged coal. The product of both washeries and dredges is mainly small coal not suitable for domestic use and the increase from those sources did not add to the supply for homes nor help in the immediate and pressing problem of providing domestic fuel.

The total production of Pennsylvania anthracite in 1918 exceeded that in 1913 by 8.0 per cent and that in 1916 by 12.8 per cent, but the output of domestic sizes, pea and larger, in 1918 exceeded that of 1913 by only 0.6 per cent and that of 1916 by 8.7 per cent.

Anthracite produced in 1890–1918.

Year.	Quantity (gross tons).	Value.	Year.	Quantity (gross tons).	Value.
1890	41,499,358	[a] $66,383,772	1913	81,718,680	$195,181,127
1895	51,785,122	[a] 82,019,272	1914	81,090,631	158,181,399
1900	51,221,353	[a] 85,757,851	1915	79,459,876	184,653,498
1905	69,339,152	[a] 141,879,000	1916	78,195,083	202,009,561
1910	75,433,246	160,275,302	1917	88,939,117	283,650,723
1911	80,771,488	175,189,392	1918	88,237,575	336,480,347
1912	75,322,855	177,022,626			

[a] Excludes value of coal used at collieries.

The facts that no price was fixed by the Government on sizes of anthracite smaller than pea and that the demand for steam coal in the east was so strong account for the large increase in the production of the steam sizes. The prices established for bituminous coal were such that the producers of the smaller sizes of anthracite could meet the competition of bituminous coal producers to advantage.

The shipments reported to the Geological Survey include those from Sullivan County, the product of dredges, and all local shipments within the region, and amounted in 1918 to 76,721,157 gross tons, valued at $317,522,181 at the breaker, an average value per gross ton of $4.14, as compared with $3.47 in 1917. Shipments of freshly mined anthracite had an average value per ton of $4.27 in 1918, against $3.58 in 1917; the average value of washery product was $2.80 in 1918 and $2.04 in 1917; and the average value of dredge product was $1.66 in 1918 and $1.50 in 1917.

The quantity of anthracite sold locally and used by employees increased from 2,127,109 gross tons, valued at $6,070,907, or $2.85 per ton, in 1917 to 2,387,892 tons, valued at $7,746,256, or $3.24 per ton in 1918.

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Anthracite produced in 1917 and 1918.

Region.	Shipments.		Sold to local trade and employees.		Mine fuel.		Total production.		Men employed.			Average number of days worked.
	Quantity (gross tons).	Value.	Quantity (gross tons).	Value.	Quantity (gross tons).	Value.	Quantity (gross tons).	Value.	Underground.	Surface.	Total.	
1917.												
Lehigh:												
Freshly mined coal	10,503,941	$37,228,470	335,488	$748,733	1,272,068	$1,415,509	12,111,497	$39,392,712	12,454	6,662	19,116	292
Washery product	953,022	2,207,667	6,187	3,471	38,624	22,317	997,833	2,233,455	.....	180	180	232
	11,456,963	39,436,137	341,675	752,204	1,310,692	1,437,826	13,109,330	41,626,167	12,454	6,842	19,296	292
Average value per ton	$3.44		$2.20		$1.10		$3.18		.....	.....	.....	.....
Schuylkill:												
Freshly mined coal	20,349,001	72,846,775	432,014	1,299,150	3,465,017	2,381,973	24,246,032	76,527,898	29,012	14,056	43,068	283
Washery product	1,634,742	3,783,948	78	292	163,439	195,147	1,798,259	3,979,387	.....	954	954	235
Dredge product	44,312	65,080	53,512	71,128	51,602	64,682	149,426	200,890	.....	121	121	166
	22,028,055	76,695,803	485,604	1,370,570	3,680,058	2,641,802	26,193,717	80,708,175	29,012	15,131	44,143	282
Average value per ton	$3.48		$2.82		$0.72		$3.08		.....	.....	.....	.....
Wyoming:												
Freshly mined coal	40,797,136	146,831,874	1,282,496	3,895,399	3,643,026	3,786,228	45,722,658	154,513,501	67,870	20,639	88,509	283
Washery product	2,777,753	4,962,053	6,928	16,957	647,009	453,209	3,431,690	5,432,219	38	1,342	1,380	[a] 390
Dredge product	2,880	5,724	.....	.....	80	140	2,960	5,864	.....	5	5	150
	43,577,769	151,799,651	1,289,424	3,912,356	4,290,115	4,239,577	49,157,308	159,951,584	67,908	21,986	89,894	284
Average value per ton	$3.48		$3.03		$0.99		$3.25		.....	.....	.....	.....
Sullivan County:												
Freshly mined coal	427,256	1,262,210	10,406	35,777	41,100	66,810	478,762	1,364,797	615	226	841	275
	427,256	1,262,210	10,406	35,777	41,100	66,810	478,762	1,364,797	615	226	841	275
Average value per ton	$2.95		$3.44		$1.63		$2.85		.....	.....	.....	.....
Total freshly mined coal	72,077,334	258,169,329	2,060,404	5,979,059	8,421,211	7,650,520	82,558,949	271,798,908	109,951	41,583	151,534	284
Average value per ton	$3.58		$2.90		$0.91		$3.29		.....	.....	.....	.....
Total washery product	5,365,517	10,953,668	13,193	20,720	849,072	670,673	6,227,782	11,645,061	38	2,476	2,514	339
Average value per ton	$2.04		$1.57		$0.79		$1.87		.....	.....	.....	.....
Total dredge product	47,192	70,804	53,512	71,128	51,682	64,822	152,386	206,754	.....	126	126	165
Average value per ton	$1.50		$1.33		$1.25		$1.36		.....	.....	.....	.....
Grand total	[b] 77,490,043	[c] 269,193,801	2,127,109	6,070,907	9,321,965	8,386,015	88,939,117	283,650,723	109,989	44,185	154,174	285
Average value per ton	$3.47		$2.85		$0.90		$3.19		.....	.....	.....	.....

[a] Part night shifts.

[b] Includes 29,760 tons sold locally and used at mines.

[c] Includes the value of 55,728 tons sold locally and used at mines.

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Anthracite produced in 1917 and 1918—Continued.

Region.	Shipments.		Sold to local trade and employees.		Mine fuel.		Total production.		Men employed.			Average number of days worked.
	Quantity (gross tons).	Value.	Quantity (gross tons).	Value.	Quantity (gross tons).	Value.	Quantity (gross tons).	Value.	Underground.	Surface.	Total.	
1918.												
Lehigh:												
Freshly mined coal	10,396,893	$42,760,882	425,749	$1,167,360	1,184,786	$1,678,221	12,007,428	$45,606,463	11,090	7,090	18,180	296
Washery product	1,155,149	3,506,859	16,612	16,834	100,297	73,947	1,272,058	3,597,640	.....	316	316	a 424
	11,552,042	46,267,741	442,361	1,184,194	1,285,083	1,752,168	13,279,486	49,204,103	11,090	7,406	18,496	298
Average value per ton	$4.01		$2.68		$1.36		$3.71		.....	.....	.....	.....
Schuylkill:												
Freshly mined coal	19,417,634	83,432,430	461,155	1,801,583	3,403,487	2,991,143	23,282,276	88,225,156	27,204	13,982	41,186	286
Washery product	2,470,038	7,257,400	914	3,429	210,660	290,462	2,681,612	7,551,291	.....	1,665	1,665	270
Dredge product	121,935	193,561	126,186	152,672	1,494	4,242	249,615	350,475	.....	238	238	186
	22,009,607	90,883,391	588,255	1,957,684	3,615,641	3,285,847	26,213,503	96,126,922	27,204	15,885	43,089	285
Average value per ton	$4.13		$3.33		$0.91		$3.67		.....	.....	.....	.....
Wyoming:												
Freshly mined coal	39,862,237	171,259,352	1,342,939	4,550,360	3,534,195	5,055,911	44,739,371	180,866,123	62,822	20,231	83,053	296
Washery product	2,881,300	7,456,647	5,233	16,484	642,373	1,000,712	3,528,906	8,473,843	.....	1,651	1,651	a 335
Dredge product	2,501	13,410	500	2,680	.....	.....	3,001	16,090	.....	14	14	240
	42,746,038	178,729,409	1,348,672	4,570,024	4,176,568	6,056,623	48,271,278	189,356,056	62,822	21,896	84,718	297
Average value per ton	$4.18		$3.39		$1.45		$3.92		.....	.....	.....	.....
Sullivan County:												
Freshly mined coal	413,470	1,641,640	8,604	34,354	51,234	117,272	473,308	1,793,266	555	263	818	259
	413,470	1,641,640	8,604	34,354	51,234	117,272	473,308	1,793,266	555	263	818	259
Average value per ton	$3.97		$3.99		$2.29		$3.79		.....	.....	.....	.....
Total freshly mined coal	70,090,234	299,094,304	2,238,447	7,554,157	8,173,702	9,842,547	80,502,383	316,491,008	101,671	41,566	143,237	293
Average value per ton	$4.27		$3.37		$1.20		$3.93		.....	.....	.....	.....
Total washery product	6,506,487	18,230,906	22,759	36,747	953,330	1,365,121	7,482,576	19,622,774	.....	3,632	3,632	313
Average value per ton	$2.80		$1.61		$1.43		$2.62		.....	.....	.....	.....
Total dredge product	124,436	206,971	126,686	155,352	1,494	4,242	252,616	366,565	.....	252	252	189
Average value per ton	$1.66		$1.23		$2.84		$1.45		.....	.....	.....	.....
Grand total	b 76,721,157	c 317,522,181	2,387,892	7,746,256	9,128,526	11,211,910	88,237,575	336,480,347	101,671	45,450	147,121	293
Average value per ton	$4.14		$3.24		$1.23		$3.81		.....	.....	.....	.....

a Part night shifts.

b Includes 37 tons sold locally.

c Includes $206, value of coal sold locally.

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SHIPMENTS.

Anthracite shipped from the Schuylkill, Lehigh, and Wyoming regions in 1807 and from 1820 to 1918, in gross tons.[a]

Year.	Schuylkill region.		Lehigh region.		Wyoming region.		Total.
	Quantity.	Percentage.	Quantity.	Percentage.	Quantity.	Percentage.	Quantity.
1807					55		55
1820			365				365
1821			1,073				1,073
1822	1,480	39.79	2,240	60.21			3,720
1823	1,128	16.23	5,823	83.77			6,951
1824	1,567	14.10	9,541	85.90			11,108
1825	6,500	18.60	28,303	81.40			34,803
1826	16,767	34.90	31,280	65.10			48,047
1827	31,360	49.44	32,074	50.56			63,434
1828	47,284	61.00	30,232	39.00			77,516
1829	79,973	71.35	25,110	22.40	7,000	6.25	112,083
1830	89,984	51.50	41,750	23.90	43,000	24.60	174,734
1831	81,854	46.29	40,966	23.17	54,000	30.54	176,820
1832	209,271	57.61	70,000	19.27	84,000	23.12	363,271
1833	252,971	51.87	123,001	25.22	111,777	22.91	487,749
1834	226,692	60.19	106,244	28.21	43,700	11.60	376,636
1835	339,508	60.54	131,250	23.41	90,000	16.05	560,758
1836	432,045	63.16	148,211	21.66	103,861	15.18	684,117
1837	530,152	60.98	223,902	25.75	115,387	13.27	869,441
1838	446,575	60.49	213,615	28.92	78,207	10.59	738,397
1839	475,077	58.05	221,025	27.01	122,300	14.94	818,402
1840	490,596	56.75	225,313	26.07	148,470	17.18	864,379
1841	624,466	65.07	143,087	14.90	192,270	20.03	959,773
1842	583,273	52.62	272,540	24.59	252,599	22.79	1,108,412
1843	710,200	56.21	267,798	21.19	285,605	22.60	1,263,598
1844	887,987	54.45	377,002	23.12	365,911	22.43	1,630,850
1845	1,131,724	56.22	429,458	21.33	451,836	22.45	2,013,013
1846	1,308,500	55.82	517,116	22.07	518,389	22.11	2,344,005
1847	1,665,735	57.79	633,507	21.98	583,067	20.23	2,882,309
1848	1,733,721	56.12	670,321	21.70	685,196	22.18	3,089,238
1849	1,728,500	53.30	781,556	24.10	732,910	22.60	3,242,966
1850	1,840,620	54.80	690,456	20.56	827,823	24.64	3,358,899
1851	2,328,525	52.34	964,224	21.68	1,156,167	25.98	4,448,916
1852	2,636,835	52.81	1,072,136	21.47	1,284,500	25.72	4,993,471
1853	2,665,110	51.30	1,054,309	20.29	1,475,732	28.41	5,195,151
1854	3,191,670	53.14	1,207,186	20.13	1,603,478	26.73	6,002,334
1855	3,552,943	53.77	1,284,113	19.43	1,771,511	26.80	6,608,567
1856	3,603,029	52.01	1,351,970	19.52	1,972,581	28.47	6,927,580
1857	3,373,797	50.77	1,318,541	19.84	1,952,603	29.39	6,644,941
1858	3,273,245	47.86	1,380,030	20.18	2,186,094	31.96	6,839,369
1859	3,448,708	44.16	1,628,311	20.86	2,731,236	34.98	7,808,255
1860	3,749,632	44.04	1,821,674	21.40	2,941,817	34.56	8,513,123
1861	3,160,747	39.74	1,738,377	21.85	3,055,140	38.41	7,954,264
1862	3,372,583	42.86	1,351,054	17.17	3,145,770	39.97	7,869,407
1863	3,911,683	40.90	1,894,713	19.80	3,759,610	39.30	9,566,006
1864	4,161,970	40.89	2,054,669	20.19	3,960,836	38.92	10,177,475
1865	4,356,959	45.14	2,040,913	21.14	3,254,519	33.72	9,652,391
1866	5,787,902	45.56	2,179,364	17.15	4,736,616	37.29	12,703,882
1867	5,161,671	39.74	2,502,054	19.27	5,325,000	40.99	12,988,725
1868	5,380,737	38.62	2,502,582	18.13	5,968,146	43.25	13,801,465
1869	5,775,138	41.66	1,949,673	14.06	6,141,369	44.28	13,866,180
1870	4,968,157	30.70	3,239,374	20.02	7,974,660	49.28	16,182,191
1871	6,552,772	41.74	2,235,707	14.24	6,911,242	44.02	15,699,721
1872	6,694,890	34.03	3,873,339	19.70	9,101,549	46.27	19,669,778
1873	7,212,601	33.97	3,705,596	17.46	10,309,755	48.57	21,227,952
1874	6,866,877	34.09	3,773,336	18.73	9,504,408	47.18	20,145,121
1875	6,281,712	31.87	2,834,605	14.38	10,596,155	53.75	19,712,472
1876	6,221,934	33.63	3,854,919	20.84	8,424,158	45.53	18,501,011
1877	8,195,042	39.35	4,332,760	20.80	8,300,377	39.85	20,828,179
1878	6,282,226	35.68	3,237,449	18.40	8,085,587	45.92	17,605,262
1879	8,900,829	34.28	4,596,567	17.58	12,586,238	48.14	26,142,630
1880	7,554,742	32.23	4,463,221	19.05	11,419,279	48.72	23,437,242

[a]1914–1918, inclusive of dredge shipments.

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Anthracite shipped from the Schuylkill, Lehigh, and Wyoming regions in 1807 and from 1820 to 1918, in gross tons—Continued.

Year.	Schuylkill region.		Lehigh region.		Wyoming region.		Total.
	Quantity.	Percentage.	Quantity.	Percentage.	Quantity.	Percentage.	Quantity.
1881	9,283,958	32.46	5,294,676	18.58	13,951,383	48.96	28,500,017
1882	9,459,288	32.48	5,680,437	19.54	13,971,371	47.98	29,120,096
1883	10,074,726	31.69	6,113,809	19.23	15,604,492	49.08	31,793,027
1884	9,478,314	30.85	5,562,226	18.11	15,677,753	51.04	30,718,293
1885	9,488,426	30.01	5,896,684	18.65	16,236,470	51.34	31,623,580
1886	9,381,407	29.19	5,728,129	17.81	17,031,826	53.00	32,136,362
1887	10,609,028	30.63	4,347,061	12.55	19,684,929	56.82	34,641,018
1888	10,654,116	27.93	5,639,236	14.78	21,852,366	57.29	38,145,718
1889	10,436,185	29.28	6,294,073	17.57	19,086,835	53.15	35,817,093
1890	10,867,822	29.68	6,329,658	17.28	19,417,979	53.04	36,615,459
1891	12,741,258	31.50	6,381,838	15.78	21,325,240	52.72	40,448,336
1892	12,526,784	30.14	6,451,076	15.40	22,515,480	54.46	41,503,340
1893	12,357,444	28.68	6,302,352	15.99	23,339,741	55.33	43,089,537
1894	12,085,005	29.06	6,705,434	16.20	22,650,761	54.72	41,391,200
1895	14,269,982	30.68	7,296,124	15.69	24,943,421	53.63	46,511,477
1896	13,097,571	30.34	6,490,441	15.03	23,589,473	54.63	43,177,485
1897	12,181,061	29.26	6,249,540	15.00	23,207,263	55.74	41,637,864
1898	12,078,875	28.83	6,253,109	14.92	23,567,767	56.25	41,899,751
1899	14,199,009	29.79	6,887,909	14.45	26,578,286	55.76	47,665,204
1900	13,502,732	29.94	6,918,627	15.33	24,686,125	54.73	45,107,484
1901	16,019,561	29.92	7,211,974	13.45	30,337,086	56.63	53,568,601
1902	8,471,391	27.15	3,470,736	11.12	19,258,768	61.73	31,200,890
1903	16,474,790	27.75	7,164,783	12.07	35,723,258	60.18	59,362,831
1904	16,379,293	28.49	7,107,220	12.36	34,006,009	59.15	57,492,522
1905	17,708,099	28.83	7,849,205	12.78	35,857,897	58.39	61,410,201
1906	16,011,285	28.75	7,046,617	12.65	32,640,693	58.60	55,698,595
1907	20,141,288	30.01	8,329,653	12.41	38,638,452	57.58	67,109,393
1908	13,006,464	27.85	7,786,255	12.04	38,872,295	60.11	64,665,014
1909	16,864,147	27.21	7,532,271	12.16	37,573,467	60.63	61,969,885
1910	17,845,020	27.49	8,627,539	13.29	38,433,227	59.22	64,905,786
1911	19,118,300	27.38	9,682,147	13.86	41,033,354	58.76	69,833,801
1912	18,213,960	28.16	8,800,125	13.61	37,653,164	58.23	64,667,249
1913	19,417,385	27.44	10,180,021	14.39	41,160,906	58.17	70,758,312
1914	18,416,586	26.33	10,272,308	14.69	41,256,463	58.98	69,947,357
1915	18,043,709	26.46	10,190,421	14.95	39,945,344	58.59	68,179,474
1916	19,677,476	29.34	9,437,545	14.07	37,945,335	56.59	67,060,356
1917	22,028,055	28.58	11,456,963	14.87	43,577,769	56.55	77,062,787
1918	22,000,607	28.84	11,552,042	15.14	42,746,038	56.02	76,307,687
	714,294,813	30.88	355,054,669	15.35	1,243,863,982	53.7	2,313,213,464

Anthracite used at the mines and breakers for steam and heat represents more than 10 per cent of the total output. In 1918 the quantity so used was 9,128,526 gross tons, or 10.35 per cent of the total output, compared with a maximum in recent years of 11.25 per cent in 1915. The percentage of fuel required for operating the mines and breakers may be expected to increase in future years because of the greater depth of the workings and because of the mining of thinner beds of coal. The more extensive development of central power stations and the use of lower grades of coal will continue as in recent years to offset the requirement of larger quantities of anthracite as mine fuel.

Production of anthracite in 1918 followed closely the record for 1917 until October, when the epidemic of influenza was severely felt in the mining regions and production decreased sharply to a minimum rate for the year in the middle of November.

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Anthracite shipped in 1917 and 1918, by regions and sizes, in gross tons.

Size.	Lehigh region.		Schuylkill region.			Wyoming region.			Sullivan County.	Total.	Percentage of total.
	Mines.	Washeries.	Mines.	Washeries.	Dredges.	Mines.	Washeries.	Dredges.	Mines.		
1917.											
Lump	15,176		104,521			34,900				154,597	0.2
Broken	485,577	1,061	1,032,732			2,990,125			22,394	4,531,889	5.9
Egg	1,386,859	12,743	2,517,914	3,478		6,456,305	11,295		41,861	10,431,455	13.5
Stove	1,902,895	14,167	3,577,834	12,888	200	8,715,512	41,829		59,180	14,324,505	18.5
Chestnut	2,296,760	176,741	4,335,248	120,871		10,594,746	159,303		69,780	17,753,449	22.8
Pea	1,066,363	87,827	2,104,780	246,012	523	3,078,971	190,471	309	48,756	6,824,003	8.8
Buckwheat No. 1	1,581,493	123,049	3,553,580	461,008	4,997	5,170,433	814,616			11,659,176	15.0
Buckwheat No. 2	806,394	168,497	1,239,449	258,882	5,434	2,389,077	1,251,822			6,119,555	7.9
Buckwheat No. 3	538,490	314,998	1,274,067	272,642	13,325	451,897	208,265			3,073,684	4.0
Boiler	294,521	51,457	366,853	227,073	18,483	645,565	82,513	2,580		1,689,075	2.2
Other[a]	179,413	1,452	242,023	31,888	1,350	269,605	17,639		185,286	928,655	1.2
	10,503,941	953,022	20,349,001	1,634,742	44,312	40,797,136	2,777,753	2,889	427,256	77,490,043	100.0
1918.											
Lump	7,211		64,346			61,972				133,529	0.2
Broken	414,153	4,314	1,156,097			3,141,248	2,245		32,263	4,750,320	6.2
Egg	1,345,485	10,764	2,464,991	8,272		6,385,431	28,108		36,912	10,279,963	13.4
Stove	1,782,206	20,710	3,228,731	13,528		8,256,966	65,819	701	54,289	13,422,950	17.5
Chestnut	2,226,055	214,623	4,109,420	134,041	171	10,480,078	167,424	930	75,399	17,408,141	22.7
Pea	1,027,559	92,452	1,937,187	375,930	1,494	2,780,922	202,614	490	52,733	6,471,381	8.4
Buckwheat No. 1	1,532,535	157,006	3,163,733	646,776	2,908	4,475,507	821,951	380		10,800,796	14.1
Buckwheat No. 2	582,759	177,273	952,041	483,742	26,802	2,031,978	1,141,427			5,396,022	7.0
Buckwheat No. 3	656,326	369,212	1,855,371	660,719	34,863	1,216,394	231,979			5,024,864	6.5
Boiler	339,727	11,111	287,750	45,198	52,419	760,140	178,844			1,675,189	2.2
Other[a]	482,877	97,684	197,967	101,832	3,278	271,601	40,889		161,874	1,358,002	1.8
	10,396,893	1,155,149	19,417,634	2,470,038	121,935	39,862,237	2,881,300	2,501	413,470	76,721,157	100.0

[a] Includes quantity reported as culm, buckwheat No. 4, screenings, settlings, silt, mine run, dirt, and slush.

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The proportions of sizes in the output of the breakers remain fairly constant from year to year. In the years 1913 to 1916 the percentage of freshly mined anthracite marketed in sizes above pea was from 62.2 to 63.3, but in 1917 and in 1918 the percentage increased to 64.7; whereas the percentage of pea size in 1913 to 1916 was from 11.2 to 12.1 but decreased in 1917 to 8.7 and in 1918 to 8.3 for the reason, it is understood, that pea coal was more or less commonly mixed with chestnut, the next larger size. The greatly increased production of washery and dredge coal is reflected in the increase in the percentage of sizes below pea in the total of all production from 26.9 per cent in 1913 and 28.5 per cent in 1916 to 30.3 per cent in 1917 and 31.6 per cent in 1918.

Anthracite shipped, 1913–1918, by sizes, in gross tons.

	Sizes above pea.		Pea.		Sizes below pea.		Total.
	Quantity (gross tons).	Percentage of total.	Quantity (gross tons).	Percentage of total.	Quantity (gross tons).	Percentage of total.	Quantity (gross tons)
1913:							
Freshly mined coal	43,781,936	63.3	8,056,919	11.6	17,366,691	25.1	69,205,546
Total shipments	43,935,224	61.6	8,209,479	11.5	19,198,469	26.9	71,343,172
1914:							
Freshly mined coal	43,112,545	62.8	8,142,829	11.8	17,472,101	25.4	68,727,475
Total shipments	43,176,836	61.3	8,277,619	11.7	19,009,591	27.0	70,464,046
1915:							
Freshly mined coal	41,125,513	62.2	8,011,934	12.1	17,036,370	25.7	66,173,817
Total shipments	41,213,703	60.0	8,210,668	12.0	19,242,085	28.0	68,666,456
1916:							
Freshly mined coal	40,575,269	63.1	7,223,529	11.2	16,568,956	25.7	64,367,754
Total shipments	40,747,215	60.4	7,520,804	11.1	19,233,344	28.5	67,501,363
1917:							
Freshly mined coal	46,640,319	64.7	6,298,870	8.7	19,138,145	26.6	72,077,334
Total shipments	47,195,895	60.9	6,824,003	8.8	23,470,145	30.3	77,490,043
1918:							
Freshly mined coal	45,323,253	64.7	5,798,401	8.3	18,968,580	27.0	70,090,234
Total shipments	45,994,903	60.0	6,471,381	8.4	24,254,873	31.6	76,721,157

Shipments by months, 1914–1918, as reported by the Anthracite Bureau of Information, are given in the following table:

Anthracite shipped in 1914–1918, by months, in gross tons.[a]

Month.	1914[b]	1915	1916	1917	1918
January	5,175,732	4,833,599	5,884,350	5,940,725	5,638,383
February	4,121,451	4,349,915	5,696,306	5,178,432	5,812,082
March	5,164,703	5,075,293	6,127,351	6,989,075	7,276,777
April	6,072,164	6,655,625	4,528,784	5,592,299	6,368,373
May	6,281,553	5,954,949	5,547,899	6,917,525	6,887,256
June	6,130,186	5,459,610	5,636,975	7,049,037	6,867,669
July	5,391,857	5,103,665	5,432,878	6,724,252	7,084,775
August	5,483,743	5,462,127	5,531,797	7,013,996	7,180,923
September	6,246,192	5,662,157	5,544,076	6,372,756	6,234,395
October	6,644,476	6,683,007	5,870,204	7,110,950	6,286,366
November	5,928,286	6,494,442	5,992,997	6,545,313	5,276,659
December	5,702,258	6,149,387	5,582,747	5,698,945	5,736,260
	68,342,601	67,883,776	67,376,364	77,133,305	76,649,918

[a] Does not include shipments from Sullivan County nor from dredges.
[b] The figures for the Lehigh & New England R. R. are not included in 1914, and the totals for this year are therefore not comparable with 1915, 1916, and 1917.

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LABOR STATISTICS.

Statistics of labor employed in the production of Pennsylvania anthracite in 1917 and 1918 are given in the following table. In the Wyoming region only were machines reported in use in the mining of anthracite in 1917, but in 1918 two machines were reported in the Schuylkill region and 15 in Sullivan County in 1918. In 1917, 155 machines were used to produce 1,745,735 gross tons; in 1918, 176 machines produced 1,658,495 gross tons. Anthracite recovered from steam-shovel pits in 1917 was 2,054,989 gross tons, compared with 2,107,306 gross tons in 1918. Seventy-six steam shovels were in use in 1917, and 82 in 1918. In 1918 there were 254 active breakers, 76 washeries, and 32 dredges compared with 244 breakers, 59 washeries, and 26 dredges in 1917.

The statistics of strikes, production by machines, and the number of steam shovels in use, as well as the number of men employed, are given in the following tables:

Men employed in the anthracite regions, 1917 and 1918, by regions.

	1917			1918		
	Underground.	Surface.	Total.	Underground.	Surface.	Total.
Lehigh district'						
Breakers	12,454	6,662	19,116	11,090	7,090	18,180
Washeries	.....	180	180	.....	316	316
Total	12,454	6,842	19,296	11,090	7,406	18,496
Change in 1918	.....	.....	.....	−1,364	+ 564	− 800
Percentage of change	.....	.....	.....	− 10.1	+ 8.3	− 4.1
Schuylkill district:						
Breakers	29,012	14,056	43,068	27,204	13,982	41,186
Washeries	.....	954	954	.....	1,665	1,665
Dredges	.....	121	121	.....	238	238
Total	29,012	15,131	44,143	27,204	15,885	43,089
Change in 1918	.....	.....	.....	−1,808	+ 754	−1,054
Percentage of change	.....	.....	.....	− 6.2	+ 5.0	− 2.4
Wyoming district:						
Breakers	67,870	20,639	88,509	62,822	20,231	83,053
Washeries	.....	1,380	1,380	.....	1,651	1,651
Dredges	.....	5	5	.....	14	14
Total	67,870	22,024	89,894	62,822	21,896	84,718
Change in 1918	.....	.....	.....	−5,048	− 128	−5,176
Percentage of change	.....	.....	.....	− 7.4	− 0.6	− 5.6
Sullivan County:						
Breakers	615	226	841	555	263	818
Change in 1918	.....	.....	.....	− 60	+ 37	− 23
Percentage of change	.....	.....	.....	− 9.8	+ 16.4	− 2.7
Grand total	109,951	44,223	154,174	101,671	45,450	147,121
Change in 1918	.....	.....	.....	−8,280	+1,227	−7,053
Percentage of change	.....	.....	.....	− 7.5	+ 2.8	− 4.6

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Labor strikes in the Pennsylvania anthracite region in 1917 and 1918.

District.	1917		1918	
	Days.	Men.	Days.	Men.
Lehigh	5	6,975	2	1,092
Schuylkill	7	4,096	4	9,945
Wyoming	4	22,819	4	7,785
Sullivan County	4	330	2	468
	5	34,220	4	19,290

Pennsylvania anthracite mined by machines in 1917 and 1918.

District.	1917		1918	
	Number.	Quantity mined (gross tons).	Number.	Quantity mined (gross tons).
Lehigh	.....	.....	.....	.....
Schuylkill	.....	.....	2	2,132
Wyoming	155	1,745,735	159	1,456,363
Sullivan County	.....	.....	15	200,000
	155	1,745,735	176	1,658,495

Pennsylvania anthracite recovered from steam-shovel strip pits in 1917 and 1918.

District.	1917		1918	
	Number of shovels used.	Quantity of anthracite from strip pits (gross tons).	Number of shovels used.	Quantity of anthracite from strip pits (gross tons).
Lehigh	41	1,434,652	42	1,324,975
Schuylkill	35	620,337	30	612,001
Wyoming	.....	.....	10	170,330
Sullivan County	.....	.....	.....	.....
	76	2,054,989	82	2,107,306

VALUE OF ANTHRACITE.

The value of anthracite reported to the Geological Survey and shown in this report is the value at the breaker, less degradation losses and selling costs. The dollars received from the sale of each size are reported and these amounts are divided by the total shipments of each size, the figure thus obtained representing the average realization price per ton.

The prices at which the sizes of anthracite above pea were sold in 1918 were those established by the Fuel Administration. For a description of the method by which these prices were determined, together with data on the cost of producing anthracite, the reader is referred to the report of the Engineers' Committee of the Fuel Administration; and for the text of the orders establishing the prices reference is made to the publication of the Fuel Administration entitled "General orders, regulations, and rulings of the United States Fuel Administration, including the acts of Congress, Executive orders,

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and proclamations of the President pursuant to which the United States Fuel Administration was created and is acting." The prices of anthracite from 1913 through 1918 are discussed in the report[1] on "Prices of coal and coke," 1913–1918, already referred to.

Value of anthracite shipped in 1917, by regions and sizes.

Size.	Lehigh region.				Schuylkill region.					
	Mines.	Average value.	Washeries.	Average value.	Mines.	Average value.	Washeries.	Average value.	Dredges.	Average value.
Lump	$71,249	$4.69	.....	.....	$454,315	$4.35	.....	.....	.....	.....
Broken	1,959,940	4.04	$3,903	$3.68	4,349,743	4.21	.....	.....	.....	.....
Egg	6,072,465	4.38	55,718	4.05	10,898,753	4.33	$14,091	$4.05	.....	.....
Stove	8,564,135	4.50	59,607	4.21	16,251,417	4.54	59,562	4.62	$800	$4.00
Chestnut	10,517,571	4.58	783,352	4.43	20,091,143	4.63	575,084	4.76	.....	.....
Pea	3,585,138	3.36	284,645	3.24	6,626,854	3.15	734,734	2.99	1,947	3.72
Buckwheat No. 1	4,159,153	2.72	357,138	2.90	9,169,133	2.58	1,171,963	2.54	8,608	1.72
Buckwheat No. 2	1,144,962	1.42	268,637	1.59	2,346,748	1.89	489,174	1.89	9,874	1.82
Buckwheat No. 3	531,103	0.97	310,956	0.99	1,894,758	1.49	381,837	1.40	14,122	1.06
Boiler	542,700	1.84	81,652	1.59	500,349	1.36	333,122	1.47	27,123	1.47
Other	80,054	0.45	2,079	1.43	263,562	1.09	24,381	0.76	2,606	1.93
	37,228,470	3.54	2,207,667	2.32	72,846,775	3.58	3,783,948	2.31	65,080	1.47

Size.	Wyoming region.						Sullivan County.		Total.	
	Mines.	Average value.	Washeries.	Average value.	Dredges	Average value.	Mines.	Average value.	Total.	Average value.
Lump	$112,072	$3.21	.....	.....	.....	.....	$89,845	$4.01	$637,636	$4.12
Broken	11,374,169	3.80	.....	.....	.....	.....	165,431	3.95	17,777,600	3.92
Egg	26,789,815	4.15	$49,673	$4.40	.....	.....	232,599	3.93	44,045,946	4.22
Stove	37,311,857	4.28	170,224	4.07	.....	.....	297,268	4.26	62,650,201	4.37
Chestnut	46,072,502	4.35	607,953	4.38	.....	.....	156,008	3.20	79,034,853	4.45
Pea	9,272,144	3.01	617,409	3.24	$1,209	$4.03	.....	.....	21,280,088	3.12
Buckwheat No. 1	10,924,967	2.15	1,399,785	1.72	.....	.....	.....	.....	27,190,747	2.33
Buckwheat No. 2	3,114,398	1.30	1,534,235	1.23	.....	.....	.....	.....	8,908,028	1.46
Buckwheat No. 3	669,001	1.48	327,591	1.57	.....	.....	.....	.....	4,129,368	1.34
Boiler	795,260	1.23	140,900	1.71	4,515	1.75	.....	.....	2,425,621	1.44
Other	395,689	1.47	24,283	1.38	.....	.....	321,059	1.73	1,113,713	1.20
	146,831,874	3.60	4,962,053	1.79	5,724	1.99	1,262,210	2.95	269,198,801	3.47

Value of anthracite shipped in 1918, by regions and sizes.

Size.	Lehigh region.				Schuylkill region.					
	Mines.	Average value.	Washeries.	Average value.	Mines.	Average value.	Washeries.	Average value.	Dredges.	Average value.
Lump	$35,906	$4.98	.....	.....	$341,755	$5.31	.....	.....	.....	.....
Broken	2,019,132	4.88	$19,844	$4.60	5,977,848	5.17	.....	.....	.....	.....
Egg	6,661,948	4.95	50,104	4.65	12,354,823	5.01	$38,442	$4.65	.....	.....
Stove	8,996,498	5.05	100,842	4.87	16,944,238	5.25	68,284	5.06	.....	.....
Chestnut	11,519,041	5.17	1,070,072	4.99	21,992,299	5.36	720,351	5.37	$882	$5.16
Pea	3,994,250	3.89	338,488	3.66	7,499,904	3.87	1,372,527	3.65	3,366	2.25
Buckwheat No. 1	5,386,401	3.51	539,462	3.44	10,834,514	3.42	2,180,857	3.37	6,985	2.40
Buckwheat No. 2	1,679,958	2.88	493,812	2.79	2,708,631	2.85	1,267,713	2.62	40,894	1.53
Buckwheat No. 3	1,226,979	1.87	602,564	1.88	3,894,526	2.10	1,387,226	2.10	64,085	1.84
Boiler	742,007	2.18	16,714	1.50	619,367	2.15	92,470	2.05	71,612	1.37
Other	498,764	1.03	184,957	1.89	264,525	1.34	129,530	1.27	5,737	1.75
	42,760,882	4.11	3,506,859	3.04	83,432,430	4.30	7,257,400	2.94	193,561	1.59

[1] U. S. Geol. Survey Mineral Resources, 1918, pt. 2, pp. 15–115, 1919.

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Value of anthracite shipped in 1918, by regions and sizes.—Continued.

Size.	Wyoming region.						Sullivan County.		Total.	
	Mines.	Average value.	Washeries.	Average value.	Dredges	Average value.	Mines.	Average value.	Total.	Average value.
Lump	$253,334	$4.08					$175,351	$5.44	$630,545	$4.72
Broken	14,693,388	4.68	$10,507	$4.68			183,719	4.98	22,896,070	4.82
Egg	30,580,834	4.79	130,700	4.65			415,424	5.51	50,000,568	4.86
Stove	40,749,943	4.94	301,478	4.58	$4,130	$5.89	283,368	5.22	67,448,781	5.02
Chestnut	52,603,486	5.02	875,112	5.23	5,310	5.71	228,073	4.33	89,201,977	5.12
Pea	10,210,551	3.67	751,303	3.71	2,450	5.00			24,400,912	3.77
Buckwheat No. 1	12,774,613	2.85	2,043,965	2.49	1,520	4.00			33,768,317	3.13
Buckwheat No. 2	4,501,572	2.22	2,328,370	2.04					13,020,950	2.41
Buckwheat No. 3	2,574,396	2.12	514,759	2.22					10,354,784	2.06
Boiler	1,685,409	2.22	428,403	2.40					3,655,982	2.18
Other	632,077	2.33	72,060	1.76			355,705	2.20	2,143,345	1.58
	171,259,352	4.30	7,456,647	2.59	13,410	5.36	1,641,640	3.97	317,822,181	4.14

BITUMINOUS COAL.

The production of bituminous coal in Pennsylvania in 1918 was 178,550,741 net tons, valued at $463,159,736, a gain, compared with 1917, of 6,102,599 tons, or 3.5 per cent, in quantity and of $41,890,928, or 9.9 per cent, in value. Important increases in production were recorded in Armstrong, Cambria, Clarion, Fayette, Green, Huntingdon, Indiana, Somerset, and Washington counties, and important decreases reported in Allegheny and Jefferson counties. The bituminous fields of Pennsylvania were divided by the Fuel Administration for administrative purposes into six divisions corresponding to the generally recognized large trade units. The statistics of production in these districts in 1917 and 1918 is given in the following table. It will be noted that each of the six districts had an increase in production in 1918.

Bituminous coal produced in Pennsylvania, 1917–1918, by districts, in net tons.

District.	1917	1918	District.	1917	1918
Central	59,044,092	61,628,709	Connellsville	34,596,903	35,676,500
Northwestern	7,381,328	8,051,383	Somerset	6,589,534	7,193,537
Pittsburgh	47,957,066	48,299,142		172,448,142	178,550,741
Westmoreland, etc	16,879,219	17,701,470			

Of the 34 railroads, large and small, that originate bituminous coal in Pennsylvania, nearly all recorded increases in the quantities of coal shipped from the mines. The increase on the Pennsylvania Railroad of nearly 8,000,000 net tons was greater than the total increase in production in the State, and was nearly 80 per cent of the total increase in shipments of bituminous coal from the mine to market. The more important roads in which there were decreases in the quantities of bituminous coal originated were the Huntingdon & Broad Top Mountain, Pennsylvania lines west of Pittsburgh, Pittsburgh & Lake Erie, Pittsburgh & Susquehanna, and Pittsburgh & West Virginia.

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Shipments from the mines, in other words, coal going to market, increased from 128,966,000 net tons in 1917 to 137,493,000 tons in 1918, a gain of 8,527,000 tons, or 6.6 per cent. Coal coked at the mines decreased from 34,707,000 tons to 32,460,000 tons, or by 7 per cent.

The number of days worked by the bituminous coal mines in Pennsylvania increased from 261 in 1917 to 269 in 1918, and to this gain is attributed the increase in production, as the average daily output per man employed increased very slightly, from 3.80 tons to 3.81 tons, and the total number of men increased by only a few hundred, from 173,968 to 174,306. The average daily output per man, all employees considered, was maintained, however, only by increased efforts on the part of the miners, for the number of underground employees decreased from 143,687 to 140,502.

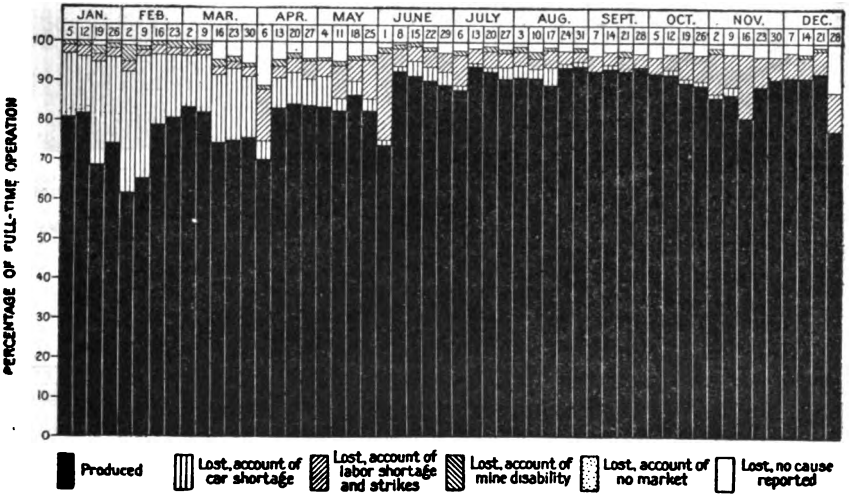

FIGURE 85.—Percentage of full-time operation of coal mines and of losses of running time, by causes and by weeks, in central Pennsylvania, 1918.

The average value per ton at the mines of bituminous coal produced in Pennsylvania increased from $2.44 in 1917 to $2.59 in 1918.

Reports on working time made by the operators weekly to the Geological Survey and the Fuel Administration in 1918 are shown in the diagrams (figs. 83, 85, 86, and 87). The central Pennsylvania field (fig. 85), in common with all other coal fields of the country, suffered from car shortage in the early months of the year. Transportation conditions improved in May and June, and through the remainder of the year they were exceedingly good.

In the Pittsburgh and Somerset districts car shortage was the principal factor limiting production (figs. 83 and 86) in the first half of 1918 and was also an important factor at periods in the last half of the year. Labor shortage and strikes appear to have been important factors in limiting output in northwestern Pennsylvania.

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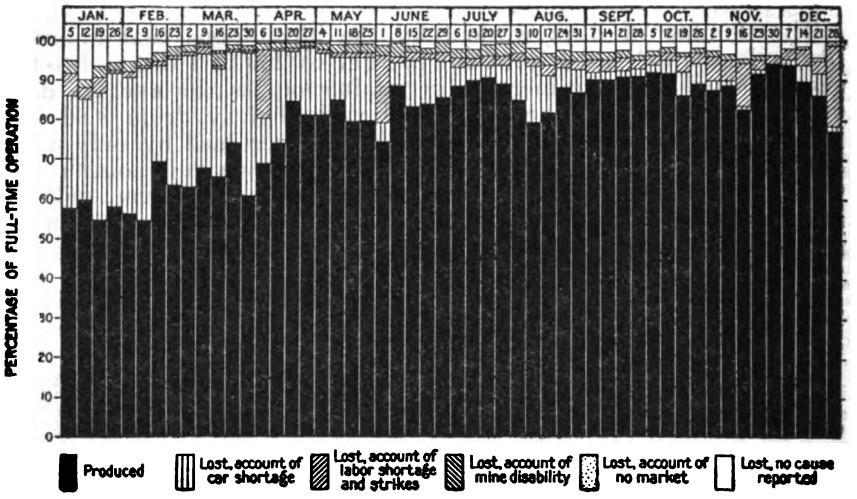

FIGURE 86.—Percentage of full-time operation of coal mines and of losses of running time, by causes and by weeks, in the Pittsburgh district of Pennsylvania, in 1918.

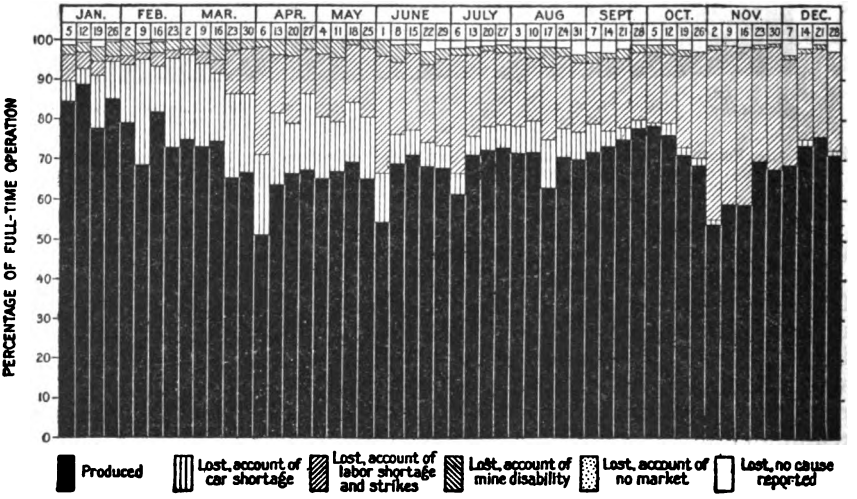

FIGURE 87.—Percentage of full-time operation of coal mines and of losses of running time, by causes and by weeks, in northwestern Pennsylvania, in 1918.

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Bituminous coal produced in Pennsylvania in 1917.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Made into coke at mines (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
						Underground.	Surface.	Total.	
Allegheny	16,538,226	999,313	297,292	1,546	17,836,377	14,261	2,591	16,852	253
Armstrong	5,200,366	145,752	228,743	.....	5,574,861	5,101	1,056	6,157	256
Beaver	103,067	25,108	988	.....	129,163	186	32	218	240
Bedford	736,625	20,979	14,427	175,022	947,053	1,316	178	1,494	250
Blair	177,325	46,900	6,857	40,516	271,598	285	80	365	266
Bradford and Lycoming	39,682	6,115	1,354	.....	47,151	65	44	109	277
Butler	1,113,461	62,942	25,560	.....	1,201,963	1,217	239	1,456	256
Cambria	16,686,302	1,353,173	293,292	1,398,003	19,730,770	19,650	3,000	22,650	253
Cameron and McKean	8,994	2,936	235	.....	12,165	38	22	60	186
Center	1,956,618	41,093	1,696	.....	1,999,407	2,044	287	2,331	253
Clarion	1,252,481	96,112	31,901	.....	1,380,494	1,484	334	1,818	251
Clearfield	8,630,851	289,400	200,701	215,581	9,336,533	9,978	1,530	11,508	253
Clinton	383,138	16,029	2,645	.....	401,812	318	70	388	297
Elk	867,606	14,438	25,143	.....	907,187	977	246	1,223	282
Fayette	9,188,001	426,296	725,731	21,742,999	32,083,027	21,885	6,481	28,366	284
Greene	732,422	19,785	25,559	122,612	900,378	811	180	991	269
Huntingdon	1,078,835	10,515	21,248	45,004	1,155,602	1,235	176	1,411	274
Indiana	11,552,915	67,923	205,572	227,356	12,053,766	10,174	2,126	12,300	272
Jefferson	4,411,280	142,859	175,967	821,552	5,551,658	4,672	929	5,601	270
Lawrence	116,407	3,622	12,900	.....	132,929	203	50	253	268
Mercer	481,615	7,722	38,084	.....	527,421	644	246	890	263
Somerset	8,987,561	235,092	231,884	.....	9,454,537	9,525	1,911	11,436	243
Tioga	821,804	33,570	11,429	.....	866,803	1,286	217	1,503	251
Washington	19,449,476	366,916	347,853	1,349,358	21,513,603	16,896	3,209	20,105	251
Westmoreland	18,444,885	443,951	571,758	8,567,188	28,027,782	19,436	5,047	24,483	264
Small mines [a]	5,994	397,200	908	.....	404,102	.....	.....	.....	.....
	128,965,937	5,275,741	3,499,727	34,706,737	172,448,142	143,687	30,281	173,968	261

[a] Includes Fulton County.

Value of bituminous coal produced in Pennsylvania in 1917.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Made into coke at mines.	Total value.	Average value per ton.
Allegheny	$43,289,192	$2,220,207	$510,525	$3,246	$46,023,170	$2.58
Armstrong	13,943,433	301,221	572,586	.....	14,817,260	2.66
Beaver	255,844	65,387	2,395	.....	323,626	2.51
Bedford	2,208,872	48,282	30,005	332,467	2,620,226	2.77
Blair	462,539	88,044	12,381	68,047	631,011	2.32
Bradford and Lycoming	120,332	19,194	3,683	.....	143,209	3.04
Butler	3,104,688	156,032	62,108	.....	3,322,828	2.76
Cambria	44,048,699	3,101,227	648,924	3,175,426	50,974,276	2.58
Cameron and McKean	29,376	7,210	585	.....	37,171	3.06
Center	5,313,461	115,676	3,141	.....	5,432,278	2.72
Clarion	3,031,385	183,321	66,841	.....	3,281,547	2.38
Clearfield	23,479,698	668,629	429,304	574,101	25,151,732	2.69
Clinton	905,814	43,712	5,978	.....	955,504	2.38
Elk	1,995,379	30,207	38,471	.....	2,064,057	2.28
Fayette	22,773,358	1,014,457	1,699,831	44,957,326	70,444,972	2.20
Greene	2,372,790	44,737	38,463	300,399	2,756,389	3.06
Huntingdon	2,829,357	25,902	53,991	71,826	2,981,576	2.58
Indiana	28,548,598	126,861	435,476	512,345	29,623,280	2.46
Jefferson	11,976,824	308,353	264,567	1,537,206	14,086,950	2.54
Lawrence	342,526	6,686	25,059	.....	374,271	2.82
Mercer	1,401,286	18,167	80,464	.....	1,499,917	2.84
Somerset	22,906,721	464,963	472,242	.....	23,843,926	2.52
Tioga	2,493,478	82,742	23,299	.....	2,599,519	3.00
Washington	50,594,230	763,244	675,221	2,350,275	54,382,970	2.53
Westmoreland	44,053,346	877,200	1,108,074	16,002,836	62,041,456	2.21
Small mines [a]	15,521	837,749	2,417	.....	855,687	2.12
	332,497,267	11,619,410	7,266,631	69,885,500	421,268,808	.....
Average value per ton	2.58	2.20	2.08	2.01	2.44	2.44

[a] Includes Fulton County.

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Bituminous coal produced in Pennsylvania in 1918.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Made into coke at mines (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
						Underground.	Surface.	Total.	
Allegheny	15,847,003	1,230,084	296,970	978	17,375,035	12,955	2,791	15,746	265
Armstrong	5,674,245	118,937	258,571	.....	6,051,753	5,173	1,249	6,422	273
Beaver	98,041	29,567	964	.....	128,572	214	46	260	256
Bedford	850,070	21,951	13,400	165,107	1,050,528	1,287	223	1,510	252
Blair	171,786	57,182	6,245	44,604	279,817	252	78	330	266
Bradford and Lycoming	19,283	10,535	1,481	.....	31,299	62	22	84	238
Butler	1,274,544	94,317	29,066	.....	1,397,927	1,353	367	1,720	253
Cambria	18,141,677	881,503	286,035	1,260,038	20,569,253	18,241	3,311	21,552	269
Cameron and McKean	5,499	1,684	300	.....	7,483	15	12	27	180
Center	1,962,108	19,793	2,763	.....	1,984,664	1,885	333	2,218	266
Clarion	1,502,101	80,314	25,226	.....	1,607,641	1,723	375	2,098	244
Clearfield	8,694,131	284,065	178,559	219,674	9,376,429	9,527	1,672	11,199	265
Clinton	341,187	15,836	3,100	.....	360,123	288	75	363	296
Elk	922,401	24,663	21,804	.....	968,868	1,277	303	1,580	254
Fayette	11,531,224	348,083	758,096	20,288,485	32,925,888	22,103	7,237	29,340	289
Greene	1,098,505	30,256	32,311	108,353	1,269,425	888	328	1,216	277
Huntingdon	1,302,328	10,475	21,206	37,553	1,371,562	1,346	233	1,579	260
Indiana	12,209,067	110,848	189,056	234,219	12,743,190	10,532	2,310	12,842	287
Jefferson	4,140,224	109,462	171,451	719,696	5,140,833	4,468	1,125	5,593	263
Lawrence	93,253	1,882	11,951	.....	107,086	166	61	227	239
Mercer	639,324	12,405	39,056	.....	690,785	720	234	954	278
Somerset	9,831,501	188,609	243,973	.....	10,264,083	8,948	2,066	11,014	250
Tioga	789,407	33,822	11,156	.....	834,385	1,090	233	1,323	257
Washington	21,369,814	435,417	391,194	1,340,838	23,537,263	16,533	3,602	20,135	256
Westmoreland	18,961,259	500,878	618,155	8,040,942	28,121,234	19,456	5,518	24,974	269
Small mines [a]	22,998	331,816	801	.....	355,615	.....	.....	.....	.....
	137,492,980	4,984,384	3,612,890	32,460,487	178,550,741	140,502	33,804	174,306	269

[a] Includes Fulton County.

Value of bituminous coal produced in Pennsylvania in 1918.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Made into coke at mines.	Total value.	Average value per ton.
Allegheny	$39,382,825	$2,921,199	$584,994	$1,467	$42,890,485	$2.47
Armstrong	16,969,624	274,010	714,795	.....	17,948,429	2.97
Beaver	262,403	77,261	2,386	.....	342,050	2.66
Bedford	2,427,519	61,615	36,211	435,445	2,960,790	2.82
Blair	493,609	154,535	17,130	118,458	783,732	2.80
Bradford and Lycoming	56,324	28,808	3,100	.....	88,232	2.82
Butler	3,761,968	268,942	80,150	.....	4,111,060	2.94
Cambria	54,055,305	2,471,327	758,954	3,623,612	60,909,198	2.96
Cameron and McKean	17,252	4,975	825	.....	23,052	3.08
Center	5,628,211	50,215	7,559	.....	5,685,985	2.86
Clarion	4,300,465	180,867	117,033	.....	4,598,365	2.86
Clearfield	25,018,478	711,021	404,731	596,758	26,730,988	2.85
Clinton	989,296	39,478	7,579	.....	1,036,353	2.85
Elk	2,637,306	70,010	59,785	.....	2,767,131	2.86
Fayette	26,322,114	762,546	1,633,280	44,100,486	72,818,426	2.21
Greene	2,931,761	60,362	62,624	254,630	3,309,377	2.61
Huntingdon	3,695,752	26,157	60,915	92,158	3,874,932	2.83
Indiana	36,153,156	270,573	505,532	646,828	37,576,089	2.95
Jefferson	12,408,728	286,249	335,408	1,629,844	14,660,229	2.85
Lawrence	252,561	4,239	30,502	.....	287,302	2.68
Mercer	1,827,919	36,149	111,099	.....	1,975,177	2.86
Somerset	28,762,663	472,486	689,712	.....	29,924,861	2.92
Tioga	2,425,923	96,046	30,548	.....	2,552,517	3.06
Washington	53,137,404	1,084,662	889,370	2,856,945	57,968,381	2.46
Westmoreland	47,930,553	1,185,930	1,301,287	16,106,849	66,524,649	2.37
Small mines [a]	70,226	738,811	2,359	.....	811,396	2.28
Average value per ton	$371,909,415 2.70	$12,338,473 2.48	$8,448,368 2.34	$70,463,480 2.17	$463,159,736 2.59	2.59

[a] Includes Fulton County.

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Bituminous coal produced in Pennsylvania, 1914–1918, in net tons.

County.	1914	1915	1916	1917	1918	Increase or decrease, 1918.
Allegheny	16,808,202	17,417,815	17,007,431	17,836,377	17,375,035	− 461,342
Armstrong	4,579,389	5,159,882	5,430,188	5,574,861	6,051,753	+ 476,892
Beaver	101,809	87,891	91,553	129,163	128,572	− 591
Bedford	634,219	635,791	721,587	947,053	1,050,528	+ 103,475
Blair	308,945	308,541	435,792	271,598	279,817	+ 8,219
Bradford and Lycoming	36,374	50,904	39,005	47,151	31,299	− 15,852
Butler	981,704	1,036,877	1,180,008	1,201,963	1,397,927	+ 195,964
Cambria	18,034,487	18,716,451	19,588,350	19,730,770	20,569,253	+ 838,483
Cameron and McKean	40,538	47,011	28,859	12,165	7,483	− 4,682
Center	1,264,075	1,430,749	1,819,007	1,999,407	1,984,664	− 14,743
Clarion	1,341,392	1,291,119	1,368,544	1,380,494	1,607,641	+ 227,147
Clearfield	7,149,023	8,022,894	8,876,823	9,336,533	9,376,429	+ 39,896
Clinton	326,545	359,275	422,062	401,812	360,123	− 41,689
Elk	963,238	1,045,554	937,583	907,187	968,868	+ 61,681
Fayette	23,336,180	28,424,067	34,249,848	32,083,027	32,925,888	+ 842,861
Greene	290,497	546,008	744,860	900,378	1,269,425	+ 369,047
Huntingdon	851,128	1,010,750	962,332	1,155,602	1,371,562	+ 215,960
Indiana	9,422,996	9,553,857	11,022,780	12,053,766	12,743,190	+ 689,424
Jefferson	5,089,623	4,895,409	5,764,525	5,551,658	5,140,833	− 410,825
Lawrence	123,987	131,746	[a] 614,994	132,929	107,086	− 25,843
Mercer	716,995	694,411	(a)	527,421	690,785	+ 163,364
Somerset	10,238,763	10,343,369	9,340,568	9,454,537	10,264,083	+ 809,546
Tioga	679,221	788,003	829,561	866,803	834,385	− 32,418
Washington	15,495,674	15,898,719	18,119,353	21,513,603	23,537,263	+ 2,023,660
Westmoreland	28,995,427	29,892,561	30,499,703	28,027,782	28,121,234	+ 93,452
Small mines	172,863	165,483	200,108	[b] 404,102	[b] 355,615	− 48,487
Total value	147,983,294 $159,006,296	157,955,137 $167,419,705	170,295,424 $221,085,175	172,448,142 $421,268,808	178,550,741 $463,159,736	+ 6,102,599 +$41,890,928

[a] Lawrence County includes Mercer County.
[b] Includes Fulton County.

SOUTH DAKOTA.

The production of lignite in Dewey, Harding, and Meade counties, South Dakota, decreased 863 tons and the production in Perkins County increased 763 tons, the net result being a decrease for the State of 100 tons. The lignite deposits of South Dakota are in a sparsely settled region and not generally within reach of the railroads. The lignite produced is for local use in the northwestern part of the State.

Lignite produced in South Dakota in 1917.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
				Underground.	Surface.	Total.	
Dewey, Harding, and Ziebach	647	2,445	3,092	9	.....	9	179
Meade	.....	995	995	10	.....	10	121
Perkins	.....	3,955	3,955	15	.....	15	161
	647	7,395	8,042	34	.....	34	154

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Value of lignite produced in South Dakota in 1917.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Total value.	Average value per ton.
Dewey, Harding, and Ziebach	$2,414	$7,792	$10,206	$3.39
Meade	.....	3,710	3,710	3.73
Perkins	.....	9,430	9,430	2.38
	2,414	20,932	23,346	.....
Average value per ton	3.73	2.83	2.90	2.90

Lignite produced in South Dakota in 1918.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
				Underground.	Surface.	Total.	
Dewey, Harding, and Ziebach	640	1,939	2,579	5	.....	5	182
Meade	.....	645	645	6	.....	6	103
Perkins	.....	4,718	4,718	10	.....	10	151
	640	7,302	7,942	21	.....	21	145

Value of lignite produced in South Dakota in 1918.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Total value.	Average value per ton.
Dewey, Harding, and Ziebach	$2,596	$6,818	$9,414	$3.65
Meade	.....	2,810	2,810	4.36
Perkins	.....	10,006	10,006	2.12
	2,596	19,634	22,230	.....
Average value per ton	4.06	2.69	2.80	2.80

Lignite produced in South Dakota, 1914–1918, in net tons.

County.	1914	1915	1916	1917	1918	Increase or decrease, 1918.
Dewey and Harding	5,142	5,645	[a] 2,326	[a] 3,092	[a] 2,579	— [a]513
Meade	625	400	781	995	645	— 350
Perkins	6,083	4,548	5,779	3,955	4,718	+ 763
	11,850	10,593	8,886	8,042	7,942	— 100
Total value	$20,456	$16,384	$18,021	$23,346	$22,230	—$1,116

[a] Includes Ziebach County.

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TENNESSEE.

The production of coal in Tennessee in 1918 was 6,831,048 tons, valued at $19,305,203, a gain of 636,827 tons, or 10.3 per cent, in quantity and of $5,712,205, or 42 per cent, in value. The average value per ton increased from $2.19 in 1917 to $2.83 in 1918. The average number of days worked increased from 241 to 265 and the number of men employed increased slightly from 10,421 in 1917 to 10,694 in 1918, the gain being about equally divided in number between men employed underground and on the surface. The average output per man per day decreased from 2.46 tons to 2.41 tons, but because of the greater number of days worked the average annual output per employee increased from 594 tons to 639 tons. Marion was the only county in Tennessee for which the statistics are shown separately to record a decrease in production.

The weekly statistics of operating conditions collected by the Geological Survey and the Fuel Administration for Tennessee are combined with southeastern Kentucky and are shown in figure 80 (p. 757). It will be noted that in this district the principal cause limiting production for the first nine months of the year was lack of cars and in the last quarter was labor and to a certain extent lack of market. The influenza epidemic was largely responsible for the low production in October and November, 1918.

Coal produced in Tennessee in 1917.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Made into coke at mines (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked
						Underground.	Surface.	Total.	
Anderson	401,022	8,002	9,534	.....	418,558	512	293	805	195
Campbell	1,055,334	49,104	34,109	149,502	1,288,049	2,010	495	2,505	199
Claiborne	1,226,996	10,275	28,368	.....	1,265,639	1,149	271	1,420	233
Fentress	428,713	317	5,005	.....	434,035	364	103	467	250
Grundy	321,076	3,234	1,127	96,312	421,749	545	250	795	288
Marion	505,928	9,026	9,742	63,849	588,545	648	313	961	283
Morgan	418,392	12,467	14,047	100,574	545,480	1,004	252	1,256	259
Overton	122,804	797	1,141	.....	124,742	108	30	138	235
Scott	101,902	12,567	2,259	.....	116,728	259	51	310	221
Other counties[a]	588,419	15,541	59,366	313,352	976,678	1,454	310	1,764	271
Small mines	.....	14,018	.....	.....	14,018	.....	.....	.....	.....
	5,170,586	135,348	164,698	723,589	6,194,221	8,053	2,368	10,421	241

[a] Bledsoe, Cumberland, Hamilton, Rhea, Roane, Sequatchie, and White.

Value of coal produced in Tennessee in 1917.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Made into coke at mines.	Total value.	Average value per ton.
Anderson	$1,002,556	$14,615	$17,124	.....	$1,034,295	$2.47
Campbell	2,953,157	96,953	68,184	$179,980	3,298,274	2.56
Claiborne	2,390,096	19,802	51,730	.....	2,470,628	1.95
Fentress	813,075	712	9,941	.....	823,728	1.90
Grundy	619,773	4,915	2,051	142,685	769,424	1.82
Marion	1,151,773	24,030	24,047	166,007	1,365,857	2.32
Morgan	1,179,932	18,830	32,788	75,430	1,306,980	2.40
Overton	246,981	1,276	1,560	.....	249,817	2.00
Scott	274,820	19,317	6,475	.....	300,612	2.58
Other counties[a]	1,233,110	31,782	99,901	574,923	1,939,716	1.99
Small mines	.....	33,667	.....	.....	33,667	2.40
	11,874,273	265,899	313,801	1,139,025	13,592,998	.....
Average value per ton	2.30	1.96	1.91	1.57	2.19	2.19

[a] Bledsoe, Cumberland, Hamilton, Rhea, Roane, Sequatchie, and White.

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Coal produced in Tennessee in 1918.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Made into coke at mines (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
						Underground.	Surface.	Total.	
Anderson	594,188	8,735	16,458	.....	619,381	707	186	893	268
Campbell	1,120,041	35,652	49,018	162,737	1,367,448	1,617	518	2,135	241
Claiborne	1,291,184	16,511	38,219	.....	1,345,914	1,113	281	1,394	277
Cumberland	43,858	450	1,080	7,739	53,127	134	37	171	157
Fentress	466,437	2,688	5,206	.....	474,331	370	93	463	277
Grundy	337,092	3,227	2,271	90,033	432,623	649	292	941	287
Marion	416,428	9,686	11,468	53,189	490,771	559	211	770	286
Morgan	534,870	14,516	15,320	80,638	645,344	954	398	1,352	274
Overton	225,765	800	827	.....	227,392	292	111	403	240
Scott	130,257	20,946	1,500	.....	152,703	270	78	348	238
Other counties [a]	744,473	23,817	40,534	202,088	1,015,912	1,533	291	1,824	273
Small mines	.....	6,102	.....	.....	6,102	.....	.....	.....	.....
	5,904,593	148,130	181,901	596,424	6,831,048	8,198	2,496	10,694	265

[a] Bledsoe, Hamilton, Rhea, Roane, Sequatchie, and White.

Value of coal produced in Tennessee in 1918.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Made into coke at mines.	Total value.	Average value per ton.
Anderson	$1,778,609	$25,494	$43,433	.....	$1,847,536	$2.98
Campbell	3,539,119	90,069	134,558	$406,843	4,170,589	3.05
Claiborne	3,527,976	43,837	98,162	.....	3,669,975	2.73
Cumberland	130,574	1,350	2,940	23,217	158,081	2.98
Fentress	1,142,424	7,218	12,046	.....	1,161,688	2.45
Grundy	901,778	8,496	5,933	234,510	1,240,717	2.87
Marion	1,204,684	27,320	32,779	146,269	1,411,052	2.88
Morgan	1,598,689	42,806	42,964	84,447	1,768,926	2.74
Overton	588,215	2,070	2,158	.....	592,443	2.61
Scott	389,471	44,277	1,530	.....	435,278	2.85
Other counties [a]	2,079,641	71,514	100,920	577,824	2,829,899	2.79
Small mines	.....	19,019	.....	.....	19,019	3.12
	16,971,180	383,470	477,443	1,473,110	19,305,203	.....
Average value per ton	2.87	2.59	2.62	2.47	2.83	2.83

[a] Bledsoe, Hamilton, Rhea, Roane, Sequatchie, and White.

Coal produced in Tennessee, 1914–1918, in net tons.

County.	1914	1915	1916	1917	1918	Increase or decrease, 1918.
Anderson	579,619	510,522	511,823	418,558	619,381	+ 200,823
Bledsoe, Rhea, Roane, Sequatchie, and White	[a]1,327,870	[a]993,257	[a]949,220	[a]976,678	[a]1,069,039	+ [a]92,361
Campbell	1,675,521	1,063,708	1,508,912	1,288,049	1,367,448	+ 79,399
Claiborne	1,371,052	1,141,142	1,550,290	1,265,639	1,345,914	+ 80,275
Fentress	(a)	259,987	300,661	434,035	474,331	+ 40,296
Grundy	(a)	305,812	335,145	421,749	432,623	+ 10,874
Hamilton	(a)	(a)	(a)	(a)	(a)	(a)
Marion	538,165	479,134	561,488	588,545	490,771	− 97,774
Morgan	371,797	371,406	349,447	545,480	645,344	+ 99,864
Overton	(a)	(a)	(a)	124,742	227,392	+ 102,650
Scott	75,174	(a)	65,104	116,728	152,703	+ 35,975
Small mines	4,060	5,398	5,339	14,018	6,102	− 7,916
Total value	5,943,258 $6,776,573	5,730,361 $6,479,916	6,137,449 $7,522,445	6,194,221 $13,592,998	6,831,048 $19,305,203	+ 636,827 +$5,712,205

[a] Bledsoe, etc., include Fentress, Grundy, Hamilton, and Overton counties in 1914; Hamilton, Overton, and Scott counties in 1915; Hamilton and Overton counties in 1916; Cumberland and Hamilton counties in 1917; and Cumberland and Hamilton counties in 1918.

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TEXAS.

The production of coal in Texas in 1918 was 2,261,135 tons, of which 1,074,183 tons was bituminous coal and 1,186,952 tons was lignite. Compared with 1917, the total in 1918 was a decrease of 94,680 tons, or 4 per cent. The production of bituminous coal decreased 185,093 tons, or 15 per cent, and the production of lignite increased 90,413 tons, or 8 per cent. The principal cause of the decrease in production of bituminous coal was lack of men, as the demand for this grade of coal was good throughout the year. In 1918 there were employed in the bituminous coal mines 2,349 men who worked an average of 273 days, compared with 2,793 men and 274 days in 1917. The number of men engaged in the mining of lignite in 1918 was 1,587, compared with 1,582 in 1917. The lignite mines averaged 244 working days in 1917 and the same in 1918.

Coal produced in Texas in 1917.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
					Underground	Surface.	Total.	
Bituminous:								
Erath, Maverick, Palo Pinto, Webb, Wise, Young	1,221,788	5,258	32,230	1,259,276	2,400	393	2,793	274
Lignite:								
Bastrop, Henderson, Hopkins, Houston, Leon, Medina, Milam, Robertson, Titus, Wood	1,070,570	8,844	17,125	1,096,539	1,283	299	1,582	244
	2,292,358	14,102	49,355	2,355,815	3,683	692	4,375	263

Value of coal produced in Texas in 1917.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam nd heat.	Total value.	Average value per ton.
Bituminous:					
Erath, Maverick, Palo Pinto, Webb, Wise, Young	$3,088,997	$17,109	$34,147	$3,140,253	$2.49
Average value per ton	2.53	3.25	1.06	2.49	.....
Lignite:					
Bastrop, Henderson, Hopkins, Houston, Leon, Medina, Milam, Robertson, Titus, Wood	1,014,224	8,136	14,995	1,037,355	.95
Average value per ton	0.95	0.92	0.88	0.95	.....
	4,103,221	25,245	49,142	4,177,608	.....
Average value per ton	1.79	1.79	1.00	1.77	1.77

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Coal produced in Texas in 1918.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
					Underground.	Surface.	Total.	
Bituminous:								
Erath, Maverick, Palo Pinto, Webb, Wise, Young	1,044,495	3,007	26,681	1,074,183	2,100	249	2,349	273
Lignite:								
Bastrop, Henderson, Hopkins, Houston, Leon, Medina, Milam, Robertson, Titus, Wood	1,159,771	8,847	18,334	1,186,952	1,291	296	1,587	244
	2,204,266	11,854	45,015	2,261,135	3,391	545	3,936	262

Value of coal produced in Texas, 1918.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Total value.	Average value per ton.
Bituminous:					
Erath, Maverick, Palo Pinto, Webb, Wise, Young	$4,126,854	$15,246	$39,009	$4,181,109	$3.89
Average value per ton	3.95	5.07	1.46	3.89	.....
Lignite:					
Bastrop, Henderson, Hopkins, Houston, Leon, Medina, Milam, Robertson, Titus, Wood	1,722,191	14,765	19,932	1,756,888	1.48
Average value per ton	1.48	1.67	1.09	1.48	.....
	5,849,045	30,011	58,941	5,937,997	.....
Average value per ton	2.65	2.53	1.31	2.63	2.63

UTAH.

The notable increase in the production of coal in Utah in 1918, from 4,125,230 tons in 1917 to 5,136,825 tons in 1918, a gain of 1,011,595 tons, or 24.5 per cent, was shared in all producing districts. Carbon County, the largest producer, had an increase of 905,301 tons. The increase was made possible by a continuous demand, more men, and an increase in the days worked.

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Coal produced in Utah in 1917.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Made into coke at mines (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
						Underground.	Surface.	Total.	
Carbon	2,898,191	53,153	81,231	669,316	3,701,891	2,256	773	3,029	222
Emery and Grand	367,318	7,126	3,283	.....	377,727	206	113	319	221
Summit and Uinta	27,249	9,277	1,614	.....	38,140	107	30	137	146
Small mines [a]	.....	7,472	.....	.....	7,472	.....	.....	.....	.....
	3,292,758	77,028	86,128	669,316	4,125,230	2,569	916	3,485	219

[a] Includes Iron County.

Value of coal produced in Utah in 1917.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Made into coke at mines.	Total value.	Average value per ton.
Carbon	$7,529,719	$89,303	$70,766	(a)	$7,689,788	$2.08
Emery and Grand	714,061	15,602	1,223	.....	730,886	1.93
Summit and Uinta	61,191	24,710	4,035	.....	89,936	2.36
Small mines [b]	.....	20,772	.....	.....	20,772	2.78
	8,304,971	150,387	76,024	(a)	8,531,382	.....
Average value per ton	2.10	1.95	.88	(a)	2.07	2.07

[a] Value of coal made into coke at the mines included in loaded at mines for shipment.
[b] Includes Iron County.

Coal produced in Utah in 1918.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Made into coke at mines (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
						Underground.	Surface.	Total.	
Carbon	3,736,898	42,042	89,950	738,302	4,607,192	2,675	1,000	3,675	261
Emery and Grand	442,892	7,476	2,804	.....	453,172	307	70	377	256
Summit and Uinta	58,928	6,489	2,224	.....	67,641	83	25	108	221
Small mines [a]	.....	8,820	.....	.....	8,820	.....	.....	.....	.....
	4,238,718	64,827	94,978	738,302	5,136,825	3,065	1,095	4,160	258

[a] Includes Iron County.

Value of coal produced in Utah in 1918.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Made into coke at mines.	Total value.	Average value per ton.
Carbon	$12,277,221	$84,033	$168,181	(a)	$12,529,435	$2.72
Emery and Grand	1,180,769	18,103	6,933	.....	1,205,805	2.66
Summit and Uinta	147,302	19,402	6,783	.....	173,487	2.56
Small mines [b]	.....	28,370	.....	.....	28,370	3.22
	13,605,292	149,908	181,897	(a)	13,937,097	.....
Average value per ton	3.21	2.31	1.92	(a)	2.71	2.71

[a] Value of coal made into coke at the mines included in loaded at mines for shipment.
[b] Includes Iron County.

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Coal produced in Utah, 1914–1918, in net tons.

County.	1914	1915	1916	1917	1918	Increase or decrease, 1918.
Carbon	2,669,511	2,671,055	3,182,244	3,701,891	4,607,192	+ 905,301
Emery	[a] 357,768	[a] 390,080	[a] 339,931	[a] 377,727	[a] 453,172	+ [a]75,445
Summit, Uinta	73,025	42,677	41,857	38,140	67,641	+ 29,501
Small mines	2,732	4,903	3,396	[b] 7,472	[b] 8,820	+ [b]1,348
Total value	3,103,036	3,108,715	3,567,428	4,125,230	5,136,825	+ 1,011,595
	$4,935,454	$4,916,016	$5,795,944	$8,531,382	$13,937,097	+$5,405,715

[a] Includes Grand County. [b] Includes Iron County.

VIRGINIA.

The production of coal in Virginia in 1918 was 10,289,808 tons, valued at $25,865,895, a gain, compared with 1917, of 202,717 tons, or 2 per cent, in quantity and of $5,740,182, or 28.5 per cent, in value. The more important increases were in Dickinson and Wise counties. Slight decreases in output were reported from Russell and Tazewell counties. The year 1918 did not differ materially from 1917 for the coal industry in Virginia; a strong demand for coal prevailed throughout the two years; the number of men employed varied only from 11,168 in 1917 to 11,004 in 1918; the average number of days worked increased by 4, from 273 to 277. Virginia and Alabama were the two fields in the east that suffered least from car shortage.

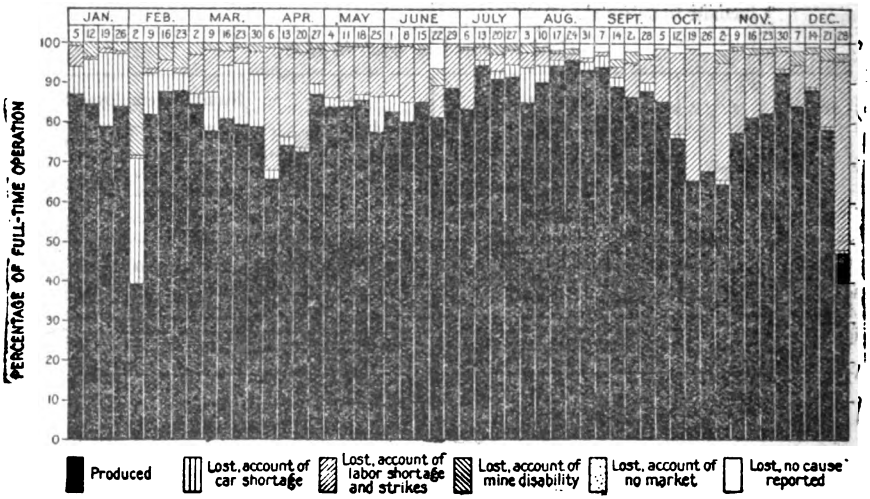

FIGURE 88.—Percentage of full-time operation of coal mines and of losses of running time, by causes and by weeks, in the southwestern and Chinch Valley districts of Virginia, in 1918.

The reports of operating conditions as reported by the operators to the Geological Survey and the Fuel Administration are shown in the accompanying diagram (fig. 88). In the first half of the year both car and labor shortage contributed to the lack of full-time operation, although car shortage was not, except in a few weeks in the early months of the year, a factor of importance. In the last quarter of

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1918 the epidemic of influenza caused a considerable cessation of operations.

Coal produced in Virginia in 1917.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Made into coke at mines (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
						Underground.	Surface.	Total.	
Dickenson	13,489	54	50	.....	13,593	58	20	78	95
Lee	855,446	6,346	9,850	.....	871,642	981	208	1,189	254
Russell	1,957,404	16,482	26,654	.....	2,000,540	1,766	342	2,108	280
Tazewell	1,497,864	26,867	26,512	80,606	1,631,849	1,334	614	1,948	228
Wise	3,327,940	80,243	65,179	1,954,093	5,427,455	4,280	1,235	5,515	295
Other counties [a] and small mines	81,483	43,543	16,986	.....	142,012	188	142	330	230
	7,733,626	173,535	145,231	2,034,699	10,087,091	8,607	2,561	11,168	273

[a] Montgomery, Pulaski, and Wythe.

Value of coal produced in Virginia in 1917.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Made into coke at mines.	Total value.	Average value per ton.
Dickenson	$32,055	$133	.....	.....	$32,188	$2.37
Lee	2,086,765	11,874	$21,275	.....	2,119,914	2.43
Russell	3,567,441	30,762	47,326	.....	3,645,529	1.82
Tazewell	3,995,301	57,205	52,238	$119,912	4,224,746	2.59
Wise	6,418,796	147,122	97,557	3,064,162	9,727,637	1.79
Other counties [a] and small mines	233,614	102,890	39,265	.....	375,699	2.65
	16,333,972	350,006	257,661	3,184,074	20,125,713	.....
Average value per ton	2.11	2.02	1.77	1.56	2.00	2.00

[a] Montgomery, Pulaski, and Wythe.

Coal produced in Virginia in 1918.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Made into coke at mines (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
						Underground.	Surface.	Total.	
Dickenson	105,435	799	4,697	.....	110,931	124	63	187	241
Lee	873,884	9,618	4,898	.....	888,400	1,038	216	1,254	267
Montgomery	38,380	5,864	4,000	.....	48,244	82	68	150	256
Russell	1,972,608	14,422	11,114	.....	1,998,144	1,872	380	2,252	289
Tazewell	1,497,161	29,663	24,686	73,226	1,624,736	1,167	346	1,513	240
Wise	3,655,532	287,056	43,695	1,527,849	5,514,132	4,428	1,080	5,508	287
Other counties [a] and small mines	45,502	45,290	14,429	.....	105,221	77	63	140	229
	8,188,502	392,712	107,519	1,601,075	10,289,808	8,788	2,216	11,004	277

[a] Pulaski and Scott.

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Value of coal produced in Virginia in 1918.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Made into coke at mines.	Total value.	Average value per ton.
Dickenson	$270,090	$869	$11,086	.....	$282,045	$2.54
Lee	2,463,765	22,335	13,923	.....	2,500,023	2.81
Montgomery	151,066	24,775	14,742	.....	190,583	3.95
Russell	4,958,439	29,113	22,228	.....	5,009,780	2.51
Tazewell	3,851,998	67,426	49,494	$165,088	4,134,006	2.54
Wise	8,928,439	636,911	107,371	3,793,926	13,466,647	2.44
Other counties [a] and small mines	204,954	70,643	7,214	.....	282,811	2.69
	20,828,751	852,072	226,058	3,959,014	25,865,895	.....
Average value per ton	2.54	2.17	2.10	2.47	2.51	2.51

[a] Pulaski and Scott.

Coal produced in Virginia, 1914–1918, in net tons.

County.	1914	1915	1916	1917	1918	Increase or decrease, 1918.
Dickenson	.....	.....	.....	13,593	110,931	+ 97,338
Lee	732,935	742,311	828,000	871,642	888,400	+ 16,758
Montgomery and Pulaski	45,151	51,141	109,543	[a] 127,836	[b] 131,448	+ [b] 3,612
Russell	1,236,114	1,493,421	1,950,036	2,000,540	1,998,144	− 2,396
Tazewell	1,323,530	1,647,061	1,588,044	1,631,849	1,624,736	− 7,113
Wise	4,620,702	4,186,309	5,228,945	5,427,455	5,514,132	+ 86,677
Small mines	1,103	2,333	2,906	14,176	22,017	+ 7,841
	7,959,535	8,122,596	9,707,474	10,087,091	10,289,808	+ 202,717
Total value	$8,032,448	$7,962,934	$10,261,424	$20,125,713	$25,865,895	+$5,740,182

[a] Includes Wythe County. [b] Includes Scott County.

WASHINGTON.

A new high record for production of coal in Washington was set in 1918 with an output of 4,082,212 tons, a gain over 1917 of 72,310 tons, or 1.8 per cent. The Roslyn field (Kittitas County), east of the mountains, and Pierce County recorded slight decreases in 1918, and King, Lewis, Thurston, and Whatcom counties had increases. The number of men employed decreased from 5,312 in 1917 to 5,109 in 1918, but the average number of days worked increased from 271 to 275.

Coal produced in Washington in 1917.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Made into coke at mines (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
						Underground.	Surface.	Total.	
King	1,215,299	18,209	80,468	.....	1,313,976	1,497	556	2,053	265
Kittitas	1,665,698	19,523	58,418	.....	1,743,639	1,410	240	1,650	289
Lewis	101,571	21,985	9,495	.....	133,051	165	41	206	244
Pierce	427,741	5,440	18,018	157,568	608,767	886	373	1,259	266
Thurston and Whatcom [a]	204,020	6,449	.....	.....	210,469	114	30	144	233
	3,614,329	71,606	166,399	157,568	4,009,902	4,072	1,240	5,312	271

[a] Includes Skagit County.

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Value of coal produced in Washington in 1917.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Made into coke at mines.	Total value.	Average value per ton.
King	$3,427,919	$53,742	$169,257	.....	$3,650,918	$2.78
Kittitas	4,419,325	47,479	96,860	.....	4,563,664	2.62
Lewis	243,699	46,924	13,711	.....	304,334	2.29
Pierce	1,248,939	15,894	37,782	$562,530	1,865,145	3.06
Thurston and Whatcom [a]	331,370	11,931	.....	.....	343,301	1.63
	9,671,252	175,970	317,610	562,530	10,727,362	.....
Average value per ton	2.68	2.46	1.91	3.57	2.68	2.68

[a] Includes Skagit County.

Coal produced in Washington in 1918.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Made into coke at mines (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
						Underground.	Surface.	Total.	
King	1,195,279	41,976	80,897	.....	1,318,152	1,397	586	1,983	266
Kittitas	1,642,000	19,626	71,782	.....	1,733,408	1,330	280	1,610	289
Lewis	138,937	3,276	8,034	.....	150,247	185	53	238	238
Pierce	409,496	8,115	28,399	154,461	600,471	777	288	1,065	278
Thurston and Whatcom [a]	274,118	1,322	4,494	.....	279,934	147	66	213	267
	3,659,830	74,315	193,606	154,461	4,082,212	3,836	1,273	5,109	275

[a] Includes Skagit County.

Value of coal produced in Washington in 1918.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Made into coke at mines.	Total value.	Average value per ton.
King	$4,828,673	$178,325	$264,731	.....	$5,271,729	$4.00
Kittitas	5,079,819	48,790	127,683	.....	5,256,292	3.03
Lewis	403,257	8,218	15,120	.....	426,595	2.84
Pierce	1,729,862	26,856	103,590	$853,039	2,713,337	4.52
Thurston and Whatcom [a]	454,204	2,128	8,584	.....	464,916	1.66
	12,495,815	264,317	519,698	853,039	14,132,869	.....
Average value per ton	3.41	3.56	2.68	5.52	3.46	3.46

[a] Includes Skagit County.

Coal produced in Washington, 1914–1918, in net tons.

County.	1914	1915	1916	1917	1918	Increase or decrease, 1918.
King	1,041,780	850,095	910,109	1,313,976	1,318,152	+ 4,176
Kittitas	1,242,800	879,392	1,318,029	1,743,639	1,733,408	− 10,231
Lewis	103,860	80,888	110,153	133,051	150,247	+ 17,196
Pierce	556,519	497,633	528,581	608,767	600,471	− 8,296
Thurston and Whatcom	119,861	121,087	171,716	[a] 210,469	[a] 279,934	+ [a] 69,465
	3,064,820	2,429,095	3,038,588	4,009,902	4,082,212	+ 72,310
Total value	$6,751,511	$5,276,299	$6,907,428	$10,727,362	$14,132,869	+$3,405,507

[a] Includes Skagit County.

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WEST VIRGINIA.

The production of coal in West Virginia in 1918 was 89,935,839 net tons, valued at $230,508,846, a gain of 3,494,172 tons, or 4 per cent, in quantity and of $29,849,478, or 14.9 per cent, in value. Among the larger producing counties, Fayette, Kanawha, McDowell, and Mercer recorded substantial decreases and Harrison, Logan, Monongalia, Preston, and Raleigh recorded considerable increases. In general, the Panhandle district comprising Ohio, Brooke, Hancock, and Marshall counties had a substantial increase in production; the Fairmont and neighboring districts in the northern part of the State had increased production, as did the Logan field in the southern part of the State; and the Kanawha district proper, on the main line of the Chesapeake & Ohio Railway, had a decrease, as did also the smokeless fields.

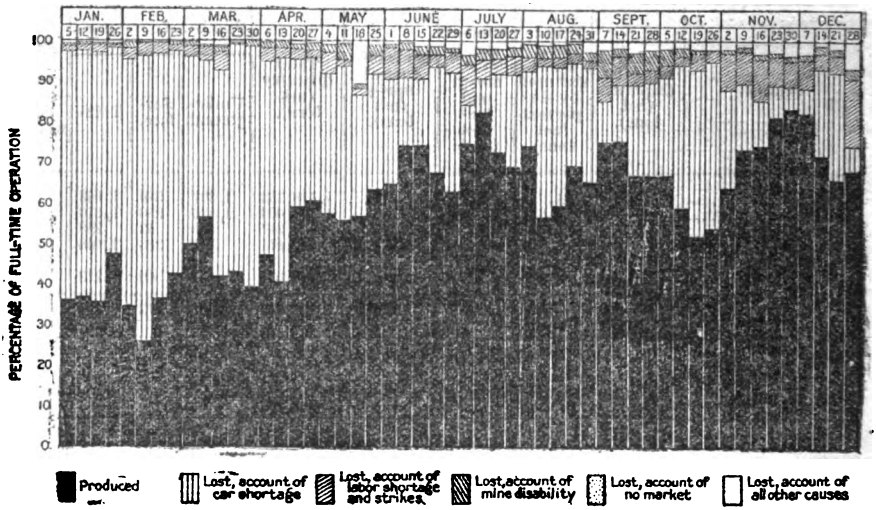

FIGURE 89.—Percentage of full-time operation of coal mines in the high-volatile coal fields of southern West Virginia, in 1918.

There was no lack of demand for coal from the fields in West Virginia in either 1917 or 1918, and the relative increases and decreases were directly attributable to relative supplies of labor and of transportation, with the exception that through failure at frequent periods in 1917 and in 1918 of central power used by the coal mines production in both the Kanawha and the New River districts was lost that, in part at least, might otherwise have been obtained.

For the State as a whole, the average number of days worked was 238 in 1918, as against 225 in 1917; the average output per man per day was 4.22 tons in 1918, compared with 4.35 in 1917; and the average annual output per man was 1,005 tons, as compared with 978 tons. The total number of men increased slightly, from 88,422 to 89,530.

The percentages of full-time operation and of losses by causes as reported by the operators to the Geological Survey and Fuel Administration in 1918 for the three principal producing districts are shown in the diagrams (figs. 89, 90, 91). In the first half of 1918 car short-

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age was the principal factor limiting production over the State. In the last half of the year labor shortage was the limiting factor of greatest importance in the smokeless fields and was of about equal

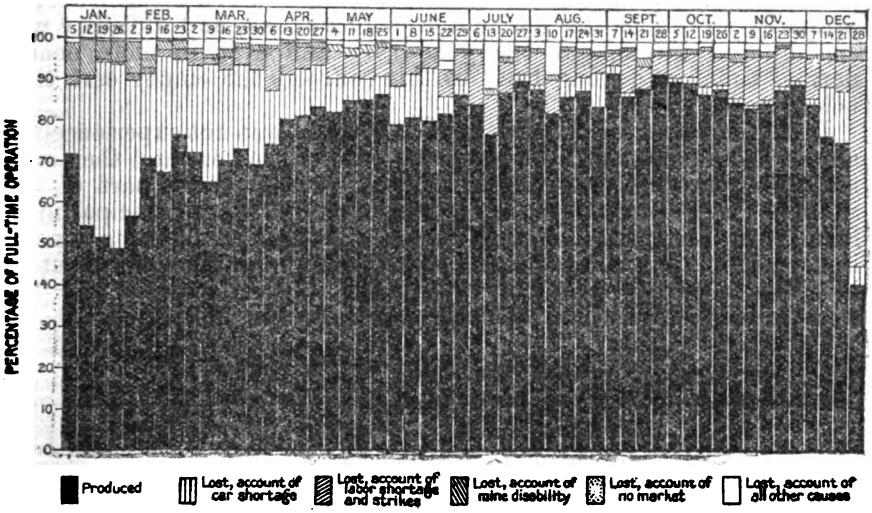

FIGURE 90.—Percentage of full-time operation of coal mines in the low-volatile coal fields of West Virginia, in 1918.

importance with car shortage in the high volatile fields in the southern part of the State. In the Fairmont field lack of cars was a factor of importance throughout 1918, though more prominent in

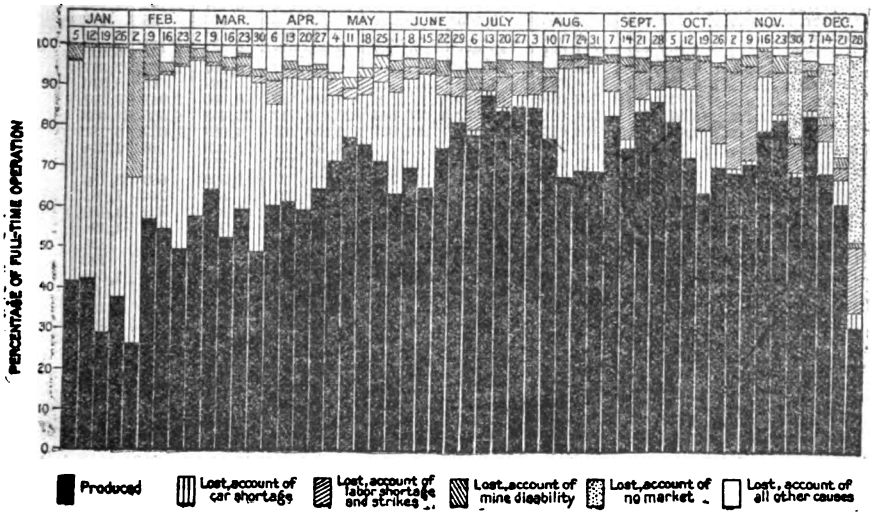

FIGURE 91.—Percentage of full-time operation of coal mines and of losses of running time, by causes and by weeks, Fairmont district of West Virginia, in 1918.

the first half than in the second half of the year. The reason for the failure of the railroads to show the same improvement in the Fairmont as in other districts lies principally in the fact that the

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Fairmont district is overdeveloped as regards coal mines with respect to the capacity of the railroads to serve the mines and transport the loaded cars out of the field to the markets. Furthermore, the Baltimore & Ohio Railroad, the principal carrier serving the fields, is primarily an originating and not a delivery road, and difficulty was encountered throughout the year 1918 and even in more nearly normal times in getting back to this railroad the empty cars that belong to it.

It will be noted further that lack of demand was not experienced in any of these fields until the last few weeks of the year and then only noticeably in the high-volatile fields in the southern part of the State. The Fairmont and smokeless fields find their principal markets in the East; the Kanawha, Logan, and Thacker districts depend in normal times to a considerable extent and under the zoning system in effect in 1918 almost entirely on the western market; and the western market was dull after the signing of the armistice.

Coal produced in West Virginia in 1917.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Made into coke at mines (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
						Underground.	Surface.	Total.	
Barbour	1,301,475	7,293	27,546	69,574	1,405,888	1,265	286	1,551	196
Boone	878,290	18,925	13,181	.....	910,396	852	251	1,133	157
Braxton	239,090	29,733	5,248	.....	274,071	246	79	325	176
Brooke	686,509	179,683	9,461	.....	875,653	1,037	307	1,344	218
Clay	512,315	6,885	10,327	.....	529,527	404	122	526	227
Fayette	8,952,720	227,637	127,504	751,941	10,059,802	9,131	2,162	11,293	246
Gilmer	102,660	2,266	3,650	.....	108,576	103	25	128	187
Hancock	2,272	9,642	.....	.....	11,914	21	.....	21	194
Harrison	5,053,402	211,681	42,651	76,457	5,384,251	3,961	1,137	5,098	188
Kanawha	6,352,009	104,615	58,383	.....	6,515,007	5,867	1,470	7,337	202
Lincoln	218,185	4,392	4,600	.....	227,177	289	81	370	154
Logan	9,213,652	142,055	53,210	.....	9,408,917	6,660	2,041	8,701	188
McDowell	16,911,836	294,661	285,572	2,556,643	20,048,712	13,468	4,565	18,033	246
Marion	4,643,011	132,613	188,860	291,621	5,256,105	4,089	1,092	5,181	213
Marshall	641,333	442,370	25,748	.....	1,109,451	1,028	186	1,214	247
Mason	162,760	26,665	9,751	.....	199,176	252	61	313	225
Mercer	2,998,959	37,119	26,908	263,741	3,326,727	2,500	680	3,180	231
Mineral	872,003	2,697	5,221	.....	879,921	839	244	1,083	224
Mingo	3,287,536	29,061	63,882	.....	3,380,479	2,927	823	3,750	236
Monongalia	915,595	7,580	6,930	197,172	1,127,277	1,211	383	1,594	204
Nicholas	179,152	18,142	2,772	.....	200,066	247	79	326	221
Ohio	458,387	160,991	14,307	.....	633,685	697	95	792	242
Preston	915,876	57,801	40,701	323,594	1,337,972	1,277	369	1,646	225
Putnam	488,879	7,067	23,727	.....	519,673	708	223	931	250
Raleigh	7,050,751	111,989	76,519	.....	7,239,259	5,684	1,502	7,186	248
Randolph	627,825	38,246	12,246	179,712	858,029	463	97	560	246
Taylor	1,375,040	4,647	13,160	466	1,393,313	1,024	242	1,266	195
Tucker	1,390,449	18,751	30,833	19,104	1,459,137	1,249	233	1,482	264
Upshur	192,287	6,272	4,005	25,600	228,164	258	113	371	149
Wayne	62,507	183	777	.....	63,467	83	30	113	204
Webster	18,707	6,262	.....	.....	24,969	40	11	51	170
Wyoming	1,087,487	13,534	3,360	.....	1,104,381	963	234	1,197	242
Other counties [a]	203,679	47,944	3,911	.....	255,534	282	44	326	262
Small mines	.....	84,991	.....	.....	84,991	.....	.....	.....	.....
	77,996,698	2,494,393	1,194,951	4,755,625	86,441,667	69,155	19,267	88,422	225

[a] Grant, Greenbrier, Lewis, Summers, and Wetzel.

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Value of coal produced in West Virginia in 1917.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Made into coke at mines.	Total value.	Average value per ton.
Barbour	$2,737,932	$14,404	$55,864	$182,913	$2,991,113	$2.13
Boone	2,460,549	33,489	24,125	.....	2,518,163	2.77
Braxton	530,216	59,796	10,953	.....	600,965	2.19
Brooke	1,854,529	429,479	15,334	.....	2,299,342	2.63
Clay	1,242,478	10,095	14,654	.....	1,267,227	2.39
Fayette	20,909,117	465,696	229,003	1,731,450	23,395,266	2.33
Gilmer	293,745	3,751	8,025	.....	305,521	2.81
Hancock	4,158	25,139	.....	.....	29,297	2.46
Harrison	11,721,064	472,624	81,934	109,847	12,385,469	2.30
Kanawha	15,084,157	172,580	106,881	.....	15,363,618	2.36
Lincoln	681,090	12,715	12,900	.....	706,705	3.11
Logan	23,106,486	264,570	88,050	.....	23,459,106	2.49
McDowell	39,429,510	496,431	487,785	3,260,540	43,674,266	2.18
Marion	10,887,190	281,197	376,929	396,016	11,941,338	2.27
Marshall	1,390,955	973,091	40,343	.....	2,404,389	2.17
Mason	431,767	60,096	18,879	.....	510,742	2.56
Mercer	7,434,666	66,858	41,204	498,125	8,040,853	2.42
Mineral	2,331,651	4,868	9,848	.....	2,346,367	2.67
Mingo	7,791,227	40,985	120,097	.....	7,952,309	2.35
Monongalia	2,231,887	16,189	17,530	553,842	2,819,448	2.50
Nicholas	487,209	36,655	6,290	.....	530,154	2.65
Ohio	1,036,419	333,989	28,789	.....	1,399,197	2.21
Preston	2,083,950	146,603	78,545	616,337	2,875,435	2.15
Putnam	1,180,970	14,510	50,632	.....	1,246,112	2.40
Raleigh	17,100,069	227,679	120,169	.....	17,447,917	2.41
Randolph	1,365,900	79,573	24,404	233,077	1,702,954	1.98
Taylor	3,164,728	7,162	26,682	2,010	3,200,582	2.30
Tucker	2,690,796	43,662	55,835	51,171	2,841,404	1.95
Upshur	597,643	9,058	8,430	56,320	671,451	2.94
Wayne	170,836	283	777	.....	171,896	2.71
Webster	47,219	15,346	.....	.....	62,565	2.51
Wyoming	2,850,259	25,740	7,350	.....	2,883,349	2.61
Other counties[a]	388,943	66,470	5,898	.....	461,311	1.81
Small mines	.....	153,477	.....	.....	153,477	1.81
	185,729,321	5,064,260	2,174,139	7,691,648	200,659,368	.....
Average value per ton	2.38	2.03	1.82	1.62	2.32	2.32

[a] Grant, Greenbrier, Lewis, Summers, and Wetzel.

Coal produced in West Virginia in 1918.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Made into coke at mines (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
						Underground.	Surface.	Total.	
Barbour	1,514,066	15,675	29,105	82,264	1,641,110	1,300	366	1,666	221
Boone	1,308,381	24,807	16,397	.....	1,349,585	948	295	1,243	238
Braxton	304,976	40,075	5,164	.....	350,215	303	101	404	195
Brooke	1,177,889	190,691	9,912	.....	1,378,492	1,118	232	1,350	241
Clay	453,771	11,764	7,224	.....	472,759	451	169	620	219
Fayette	8,413,969	223,818	125,873	815,246	9,578,906	8,915	2,321	11,236	240
Gilmer	64,175	2,885	2,142	.....	69,202	113	29	142	172
Grant	309,097	2,014	5,697	.....	316,808	205	76	281	273
Hancock	4,542	8,130	.....	.....	12,672	14	1	15	221
Harrison	5,391,941	106,673	43,912	80,391	5,622,917	4,116	1,284	5,400	207
Kanawha	6,062,603	121,824	47,004	.....	6,231,431	5,390	1,575	6,965	209
Lewis	52,322	47	103	.....	52,472	58	29	87	196
Lincoln	271,349	3,424	5,012	.....	279,785	298	86	384	203
Logan	11,129,976	85,957	44,450	7,888	11,268,271	6,911	2,114	9,025	222
McDowell	15,927,649	229,908	297,308	2,207,756	18,662,621	12,545	4,150	16,695	262
Marion	4,583,622	41,168	177,578	406,601	5,208,969	4,381	1,214	5,595	224
Marshall	593,900	481,075	27,787	.....	1,102,762	921	153	1,074	247
Mason	154,896	73,886	12,495	.....	241,277	275	75	350	222
Mercer	2,905,740	39,617	25,469	203,590	3,174,416	2,437	651	3,088	248
Mineral	845,727	7,839	4,347	.....	857,913	736	289	1,025	230
Mingo	3,274,227	89,520	55,836	.....	3,419,583	2,600	981	3,581	253
Monongalia	2,103,317	47,410	5,937	197,514	2,354,178	1,723	584	2,307	228
Nicholas	161,537	16,248	1,438	3,858	183,081	195	84	279	233

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Coal produced in West Virginia in 1918—Continued.

County.	Loaded at at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used in mines for steam and heat (net tons).	Made into coke at mines (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
						Underground.	Surface.	Total.	
Ohio	473,311	287,939	24	.....	761,274	672	87	759	270
Preston	1,255,928	163,621	35,124	333,538	1,788,211	1,589	492	2,081	243
Putnam	333,749	7,268	11,931	.....	352,948	552	130	682	261
Raleigh	7,274,359	119,305	90,165	.....	7,483,829	5,710	1,579	7,289	250
Randolph	796,422	33,217	11,083	175,850	1,016,572	533	139	672	261
Taylor	1,327,812	2,845	13,554	3,910	1,348,121	1,039	252	1,291	197
Tucker	1,331,152	16,025	38,233	16,260	1,401,670	1,292	277	1,569	278
Upshur	428,266	8,765	4,712	24,521	466,264	329	157	486	188
Wayne	71,202	376	661	.....	72,239	98	33	131	238
Webster	25,347	5,452	.....	.....	30,799	52	11	63	186
Wyoming	1,218,760	14,168	3,400	.....	1,236,328	1,056	435	1,491	254
Other counties [a]	33,936	51,783	874	.....	86,593	172	32	204	214
Small mines	.....	61,566	.....	.....	61,566	.....	.....	.....	.....
	81,579,916	2,636,785	1,159,951	4,559,187	89,935,839	69,047	20,483	89,530	238

[a] Greenbrier, Summers, and Wetzel.

Value of coal produced in West Virginia in 1918.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Made into coke at mines.	Total value.	Average value per ton.
Barbour	$3,806,351	$36,053	$127,765	$213,940	$4,184,109	$2.55
Boone	3,374,448	49,167	33,094	.....	3,456,704	2.56
Braxton	853,329	95,990	10,203	.....	959,522	2.74
Brooke	3,070,592	573,806	21,721	.....	3,666,119	2.66
Clay	1,249,550	29,706	19,514	.....	1,298,770	2.75
Fayette	22,982,816	540,321	294,686	2,186,101	26,003,924	2.71
Gilmer	168,502	6,535	4,655	.....	179,692	2.60
Grant	821,559	4,087	9,735	.....	835,381	2.64
Hancock	13,431	20,357	.....	.....	33,788	2.67
Harrison	13,358,389	261,783	102,591	199,046	13,921,809	2.48
Kanawha	15,804,100	262,103	92,523	.....	16,158,726	2.59
Lewis	136,499	85	257	.....	136,841	2.61
Lincoln	704,772	6,174	11,985	.....	722,931	2.58
Logan	28,951,053	172,573	83,187	19,720	29,226,533	2.59
McDowell	38,896,434	457,178	648,429	4,338,829	44,340,870	2.38
Marion	11,598,697	97,200	426,272	962,664	13,084,833	2.51
Marshall	1,455,704	1,147,817	58,144	.....	2,661,665	2.41
Mercer	7,283,703	79,651	55,043	402,180	7,820,577	2.46
Mason	433,034	189,682	30,530	.....	653,246	2.71
Mineral	2,327,142	16,115	9,109	.....	2,352,366	2.74
Mingo	8,338,129	198,270	116,320	.....	8,652,719	2.53
Monongalia	5,367,150	128,877	13,108	577,875	6,087,010	2.59
Nicholas	451,008	92,760	2,859	9,285	555,912	3.04
Ohio	1,089,273	678,713	60	.....	1,768,046	2.32
Preston	3,392,619	452,643	92,601	904,958	4,842,821	2.71
Putnam	864,405	16,560	24,935	.....	905,900	2.57
Raleigh	20,475,506	291,414	233,573	.....	21,000,493	2.81
Randolph	2,015,043	77,311	21,883	430,333	2,545,670	2.50
Taylor	3,424,300	7,403	25,699	17,293	3,474,695	2.58
Tucker	3,578,213	35,390	75,675	45,528	3,734,806	2.66
Upshur	1,151,196	17,070	11,832	57,251	1,237,449	2.65
Wayne	206,694	596	1,652	.....	208,942	2.89
Webster	66,888	13,425	.....	.....	80,313	2.61
Wyoming	3,342,292	28,263	7,150	.....	3,377,705	2.73
Other counties [a]	94,738	116,589	977	.....	212,304	2.45
Small mines	.....	125,655	.....	.....	125,655	2.04
	211,148,254	6,327,322	2,667,767	10,365,503	230,508,846	.....
Average value per ton	2.59	2.40	2.30	2.27	2.56	2.56

[a] Greenbrier, Summers, and Wetzel.

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Coal produced in West Virginia, 1914–1918, in net tons.

County.	1914	1915	1916	1917	1918	Increase or decrease in 1918.
Barbour	1,331,948	1,320,069	1,367,109	1,405,888	1,641,110	+ 235,222
Boone	592,558	661,898	759,736	910,396	1,349,585	+ 439,189
Braxton	306,608	(a)	329,528	274,071	350,215	+ 76,144
Brooke	554,870	615,446	720,252	875,653	1,378,492	+ 502,839
Clay	563,561	584,205	480,712	529,527	472,759	− 56,768
Fayette	9,038,738	10,182,958	10,998,020	10,059,802	9,578,906	− 480,896
Gilmer	114,876	148,125	125,481	108,576	69,202	− 39,374
Grant	179,642	215,935	203,059	(a)	(a)	(a)
Greenbrier and Lewis	b 265,664	c 590,358	d 330,070	e 255,534	f 455,873	+ f 200,339
Hancock	(a)	(a)	4,763	11,914	12,672	+ 758
Harrison	5,291,683	5,112,181	5,186,974	5,384,251	5,622,917	+ 238,666
Kanawha	5,989,055	5,305,224	6,027,142	6,515,007	6,231,431	− 283,576
Lincoln	(a)	44,956	183,266	227,177	279,785	+ 52,608
Logan	6,618,951	7,918,963	9,412,402	9,408,917	11,268,271	+1,859,354
McDowell	14,588,564	17,411,439	20,485,125	20,048,712	18,662,621	−1,386,091
Marion	6,731,542	6,689,713	6,097,069	5,256,105	5,208,969	− 47,136
Marshall	1,153,126	990,960	1,209,604	1,109,451	1,102,762	− 6,689
Mason	121,911	122,779	119,637	199,176	241,277	+ 42,101
Mercer	2,961,141	3,489,049	3,693,171	3,326,727	3,174,416	− 152,311
Mineral	633,406	660,250	692,250	879,921	857,913	− 22,008
Mingo	2,839,014	2,871,739	3,474,137	3,380,479	3,419,583	+ 39,104
Monongalia	414,821	400,222	590,339	1,127,277	2,354,178	+1,226,901
Nicholas	(a)	(a)	(a)	200,066	183,081	− 16,985
Ohio	570,347	576,867	637,953	633,685	761,274	+ 127,589
Preston	1,240,650	1,239,614	1,279,082	1,337,972	1,788,211	+ 450,239
Putnam	544,859	547,669	604,348	519,673	352,948	− 166,725
Raleigh	5,454,059	5,883,485	6,989,772	7,239,259	7,483,829	+ 244,570
Randolph	520,360	451,696	732,297	858,029	1,016,572	+ 158,543
Taylor	1,308,704	1,068,594	1,466,124	1,393,313	1,348,121	− 45,192
Tucker	1,504,215	1,651,567	1,290,735	1,459,137	1,401,670	− 57,467
Upshur	119,757	98,147	159,187	228,164	466,964	+ 238,100
Wayne	(a)	(a)	(a)	63,467	72,239	+ 8,772
Webster	(a)	(a)	21,799	24,969	30,799	+ 5,830
Wyoming	75,058	343,735	699,681	1,104,381	1,236,328	+ 131,947
Small mines	77,938	86,246	89,897	84,991	61,566	− 23,425
Total value	71,707,626 $71,391,408	77,184,069 $74,561,349	86,460,127 $102,366,092	86,441,667 $200,659,368	89,935,839 $230,508,846	+3,494,172 +$29,849,478

a Included with Greenbrier and other counties.
b Includes Hancock, Lincoln, Nicholas, Wayne, and Webster counties.
c Includes Braxton, Hancock, Nicholas, Wayne, and Webster counties.
d Includes Nicholas and Wayne counties.
e Includes Grant, Summers, and Wetzel; and increase in Nicholas and Wayne counties.
f Includes Grant, Summers, and Wetzel.

WYOMING.

The production of coal in Wyoming increased from 8,575,619 tons in 1917 to 9,438,688 tons in 1918, a gain of 863,069 tons, or 10.1 per cent. Substantial increases were recorded in Sheridan County and in the Rock Spring field (Sweetwater County), but the Kemmerer field (Lincoln County) had a small decrease. The number of men employed increased from 7,358 in 1917 to 7,554 in 1918, and the average number of days worked increased from 246 to 268. The average output per man per day, however, dropped from 4.74 tons in 1917 to 4.66 in 1918, but, because of the greater number of days worked, the average annual output increased from 1,165 tons in 1917 to 1,249 tons in 1918—the highest average recorded in any State in 1918.

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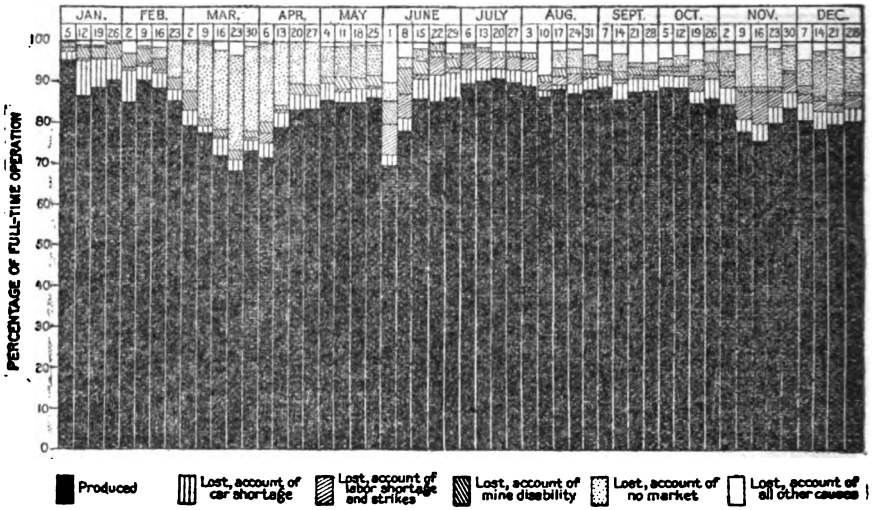

FIGURE 92.—Percentage of full-time operation of coal mines and of losses of running time, by causes and by weeks, in the Rocky Mountain and Pacific coast region, in 1918.

Coal produced in Wyoming in 1917.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
					Underground.	Surface.	Total.	
Carbon and Uinta	860,191	14,935	33,600	908,726	569	168	737	295
Fremont, Hot Springs, and Park	692,342	43,282	35,941	771,565	526	124	650	258
Converse, Johnson, and Weston	327,397	7,882	21,578	356,857	313	61	374	284
Lincoln	1,837,567	12,668	90,578	1,940,813	1,243	242	1,485	287
Sheridan	1,620,137	12,998	40,284	1,673,419	1,152	317	1,469	199
Sweetwater	2,842,060	29,599	48,460	2,920,119	2,221	422	2,643	228
Small mines		4,120		4,120				
	8,179,694	125,484	270,441	8,575,619	6,024	1,334	7,358	246

Value of coal produced in Wyoming in 1917.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Total value.	Average value per ton.
Carbon and Uinta	$1,445,621	$45,163	$38,515	$1,529,299	$1.68
Fremont, Hot Springs, and Park	1,723,049	112,119	28,659	1,863,827	2.42
Converse, Johnson, and Weston	748,565	16,695	25,130	790,390	2.21
Lincoln	3,457,785	23,301	81,050	3,562,136	1.84
Sheridan	3,248,270	21,331	47,586	3,317,187	1.98
Sweetwater	5,410,299	56,193	52,305	5,518,797	1.89
Small mines		11,647		11,647	2.83
	16,033,589	286,449	273,245	16,593,283	
Average value per ton	1.96	2.28	1.01	1.93	1.93

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Coal produced in Wyoming in 1918.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
					Underground	Surface.	Total.	
Carbon and Uinta	756,180	12,682	28,779	797,641	521	222	743	291
Fremont, Hot Springs, and Park	727,267	17,002	45,163	789,432	565	135	700	281
Converse, Johnson, and Weston	327,490	18,009	21,616	367,115	264	62	326	297
Lincoln	1,817,162	11,660	84,075	1,912,897	1,188	262	1,450	277
Sheridan	1,851,832	42,205	23,039	1,917,076	1,055	406	1,461	198
Sweetwater	3,575,321	25,930	49,987	3,651,238	2,339	535	2,874	286
Small mines		3,289		3,289				
	9,055,252	130,777	252,659	9,438,688	5,932	1,622	7,554	268

Value of coal produced in Wyoming in 1918.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Total value.	Average value per ton.
Carbon and Uinta	$1,615,242	$36,347	$58,983	$1,710,572	$2.14
Fremont, Hot Springs and Park	2,151,178	58,744	76,537	2,286,459	2.90
Converse, Johnson, and Weston	907,058	52,675	47,014	1,006,747	2.74
Lincoln	4,217,322	27,666	97,169	4,342,157	2.27
Sheridan	4,696,433	64,632	41,648	4,802,713	2.51
Sweetwater	8,280,382	45,288	96,357	8,422,025	2.31
Small mines		10,346		10,346	3.15
	21,867,615	295,696	417,708	22,581,019	
Average value per ton	2.41	2.26	1.65	2.39	2.39

Coal produced in Wyoming, 1914–1918, in net tons.

County.	1914	1915	1916	1917	1918	Increase or decrease, 1918.
Carbon and Uinta	684,618	669,652	790,813	908,726	797,641	− 111,085
Converse, Johnson, and Weston	364,540	355,074	[a] 366,744	356,857	367,115	+ 10,258
Fremont, Hot Springs, and Park	429,539	497,601	644,435	771,565	789,432	+ 17,867
Lincoln	1,482,421	1,416,301	1,888,709	1,940,813	1,912,897	− 27,916
Sheridan	1,001,411	978,623	1,314,063	1,673,419	1,917,076	+ 243,657
Sweetwater	2,509,371	2,632,244	2,901,220	2,920,119	3,651,238	+ 731,119
Small mines	3,393	4,533	4,663	4,120	3,289	− 831
	6,475,293	6,554,028	7,910,647	8,575,619	9,438,688	+ 963,069
Total value	$10,033,747	$9,555,804	$12,239,707	$16,593,283	$22,581,019	+$5,987,736

[a] Johnson and Weston counties only.

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LIME.

By G. F. Loughlin and Herbert Insley.[1]

INTRODUCTION.

The growing interest in the many features of the lime industry was hastened by war conditions, especially in 1918, when it became imperative for the War Industries Board and other Government organizations, as well as for the producers and consumers of lime in general, to know the distribution of lime plants in the United States and the uses for which their product was sold, in order that the more essential demands for lime could be supplied most economically. To this end the United States Geological Survey was requested to prepare a map setting forth this information for the War Industries Board and the War Service Committee.

The location and relative production of different manufacturing centers and the kinds of lime produced in each have proved to be of such general interest that these features of the map are here shown on Plate VI. This map, it is hoped, will be followed by a map showing, in addition to the present data, the extent of high-calcium and high-magnesium formations in so far as they can be separately mapped and also by a bulletin describing the limestones and dolomites of the country.

Inquiries from the war boards and commissions also called for statistical information in much more detail than it had heretofore been believed practicable or even possible to collect. The Geological Survey was able to supply some of this information from unpublished miscellaneous records, but the remainder had to be obtained by request directly from producers, many of whom had not kept such detailed records of their sales. Because of the importance of these details and the desirability of having itemized data on production in times of peace and war, and because also of the more practical use now made of statistics by the more progressive lime manufacturers, the statistical blanks sent out by the Survey in 1918 called for a much greater subdivision of sales according to uses than ever before. The results of the canvass are most conspicuous in the tables showing lime sold to chemical works and miscellaneous manufacturing industries grouped under "other uses." Collection of this great amount of information has necessarily delayed completion of the report, but the present and future value of the results justify the delay.

Another feature of this report is the introduction of several diagrams showing changes in the value and prices of lime and the quantities sold for different uses. Attention is particularly directed to Plate VIII, which shows the average prices for different kinds of lime, and to figures 94 and 95, which show progressive changes in the relative quan-

[1] The statistical tables of this report were prepared by Miss A. T. Coons, with the exception of those on imports and exports, which were compiled from records of the Bureau of Foreign and Domestic Commerce by J. A. Dorsey, both of the United States Geological Survey.

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tity of lime devoted to the more important uses, notably the prevailing decline in building lime and, in recent years, of agricultural lime and the general increase in chemical and "other" lime.

On February 3, 1919, a preliminary estimate was published by the Survey giving the total quantity of lime produced and sold in the United States and the quantity produced and sold in the leading States. A general review of the industry by districts was included, as well as a survey of the conditions affecting the quantity of lime sold for the different uses. This preliminary estimate closely approximated the actual figures. The estimated total quantity of lime produced and sold was 3,028,000 tons, which was only 178,016 tons short of the actual quantity—an underestimate of about 5.6 per cent.

The situation in the lime industry in 1918 was such as to make necessary many radical readjustments. Producers who were not able or willing to make such readjustments were forced to close down their plants. This was especially true of the producers who did business on a very small scale.

The great handicaps to production in 1918 were scarcity of labor, scarcity of coal and other supplies, and war restrictions on building operations. The scarcity of labor, coal, and other supplies made their cost much higher than in preceding years. To meet this rising cost, producers tried to increase the price of lime in proportion, but in many sections of the country this increase was impossible owing to the keenness of competition. Where fuel was very scarce, producers were often compelled to run their kilns intermittently, thus further increasing the cost of production. War restrictions on building decreased the demand greatly in those States where lime was manufactured principally for building; but in States where much lime is used in manufacturing industries the demand was fair or even very good, the increased demand for chemical or "other" lime usually making up for the lack of demand for building lime. As a rule, it was inability to take care of the demand, owing to scarcity of labor and lack of fuel, that caused the decrease in output. Scarcity of labor apparently played as great a part in cutting down the output as lack of fuel. When labor could be obtained it was usually of an inferior quality. Lack of shipping facilities was also a great handicap to producers, although it did not seem so great a factor in the decrease of production as scarcity of labor and fuel and the war restrictions.

LIME SOLD IN 1918.

Lime burned and sold in the United States in 1909–1918.

	Quantity (short tons).	Value.[a]	Average price per ton.	Number of plants in operation.
1909	3,484,974	$13,846,072	$3.98	1,282
1910	3,505,954	14,088,039	4.02	1,125
1911	3,392,915	13,689,054	4.03	1,139
1912	3,529,462	13,970,114	3.96	1,017
1913	3,595,390	14,648,362	4.07	1,023
1914	3,380,928	13,268,938	3.92	954
1915	3,622,810	14,424,036	3.98	906
1916	4,073,433	18,509,305	4.54	778
1917	3,786,364	23,807,877	6.29	595
1918	3,206,016	26,808,909	8.36	496
Percentage of increase or decrease in 1918	−15.3	+12.6	.....	.....

[a] The value given represents the value of bulk lime f. o. b. at point of shipment and does not include weight or cost of barrel or package.

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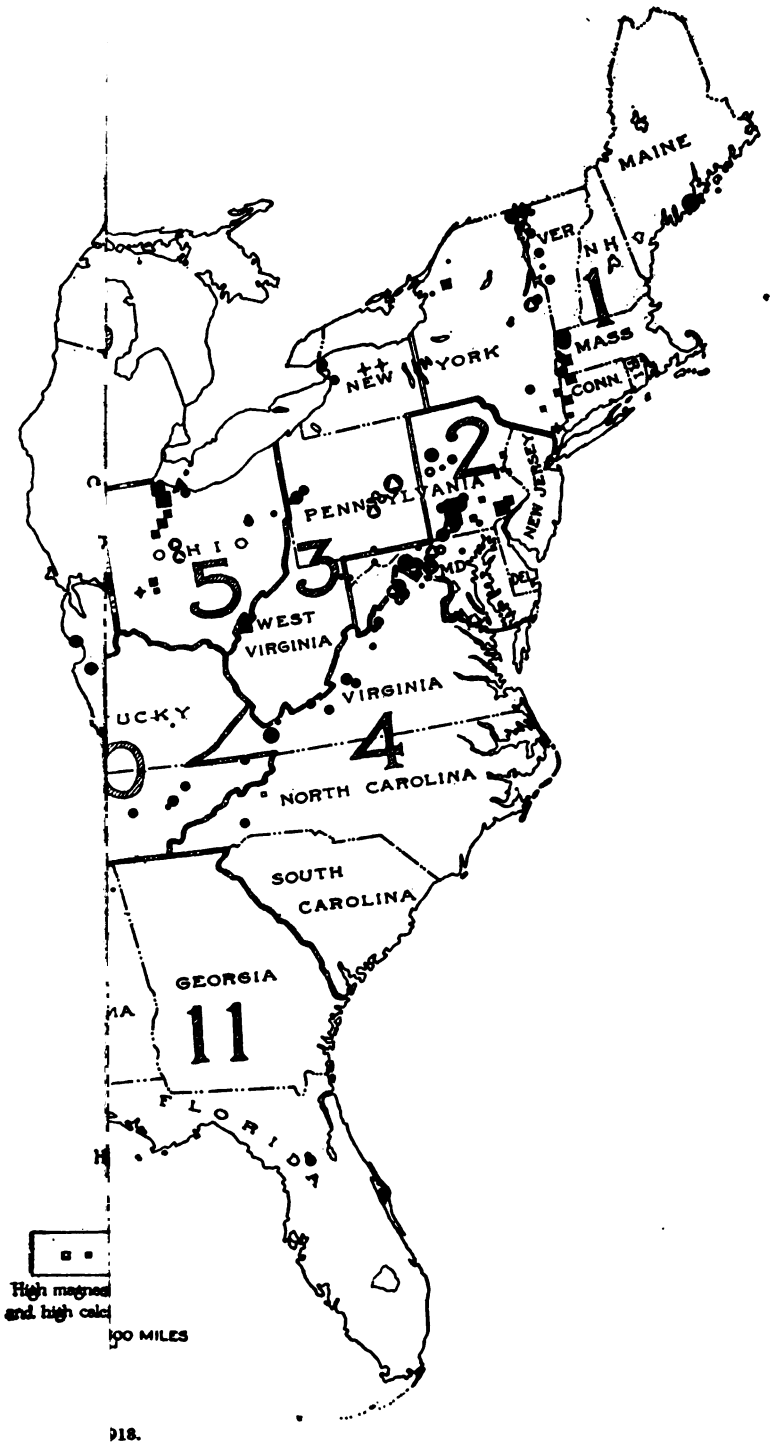

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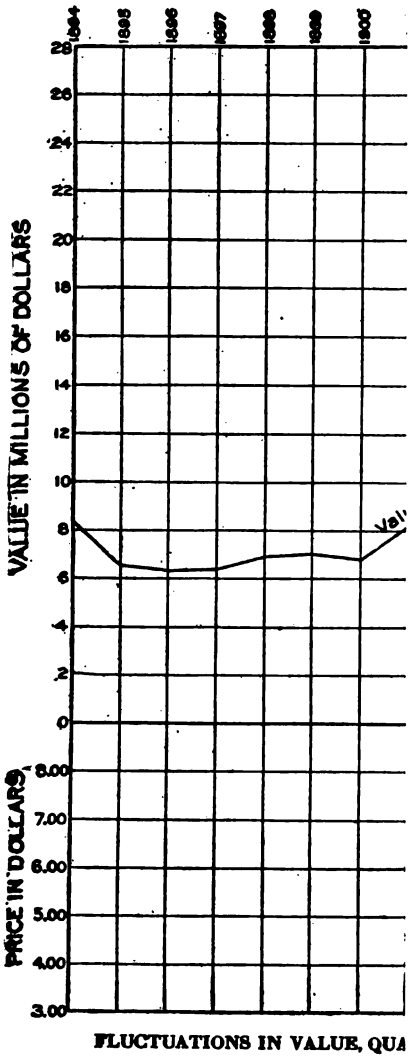

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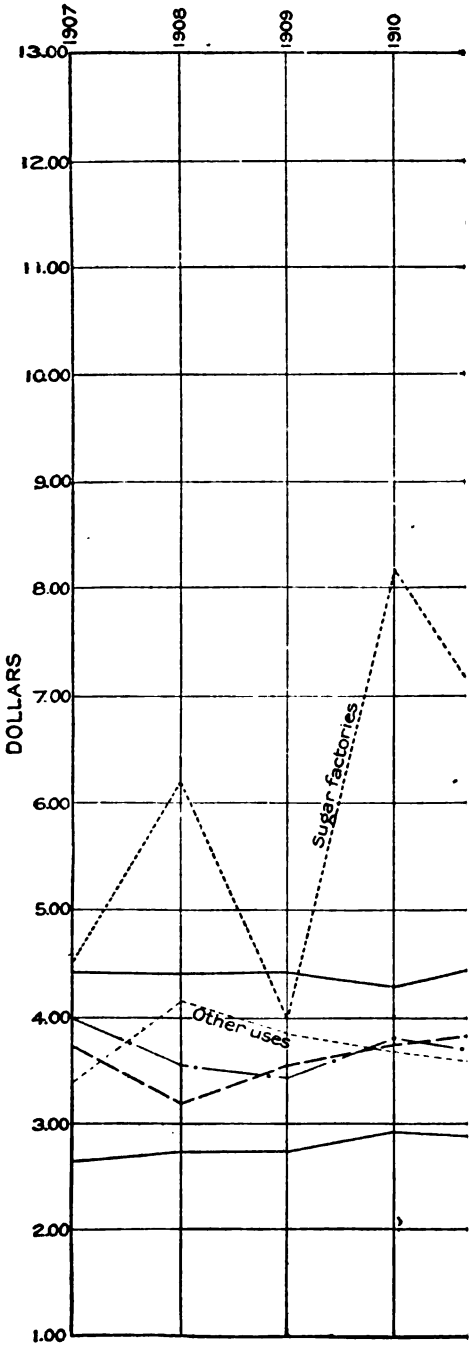

AVERAGE PRICE E

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The total quantity of lime sold in 1918 was 3,206,016 short tons, valued at $26,808,909—a decrease in quantity of 580,348 tons, or 15 per cent, but an increase in value of $3,001,032, or 13 per cent, compared with the production in 1917. The greatest quantity of lime sold in any one year was recorded in 1916, when 4,073,433 tons was produced and sold. In value, however, the highest mark was reached in 1918 (Pl. VII).

The average price per ton of lime increased from $6.29 in 1917 to $8.36 in 1918. This was an increase of 33 per cent over the price for 1917 and of 113 per cent over the price for 1914 (Pls. VII and VIII). The increase in price was due in great part to the increase in the cost of labor, fuel, and all other supplies. Decrease in price in 1918 was recorded only in Hawaii, Montana, and Wyoming, all small producing States. The greatest increase in price was in Florida, where the average price per ton rose from $5.74 in 1917 to $13.58 in 1918. The average price per ton in Wyoming was $18.75, the highest price in any State, although this was in fact a decrease from $21.93 a ton in 1917. The high price in Wyoming was undoubtedly caused by the isolation of the State and the difficulty of transportation to and from other States. The fact that both Wyoming and Rhode Island showed comparatively small outputs from single producers probably also accounts in part for the high price per ton.

The plants in operation in 1918 numbered 496, the smallest number yet recorded by the Geological Survey, and a decrease from 1917 of 99 plants. The percentage of decrease in the number of plants (16.6 per cent) was approximately the same as the percentage of decrease in quantity of lime (15.3 per cent), although in the last few years the tendency has been for the decrease in plants to be much more rapid than the decrease in production. The greater number of plants that discontinued operations in 1918, as in former years, were very small producers. The fact that fewer plants shut down in 1918 than in either 1917 or 1916 suggests that the elimination of the small strictly local producer is approaching completion.

Lime in 1918 was burned and sold in 40 States and 2 Territories. Sales increased in only 4 States and in Porto Rico. Kentucky showed the greatest percentage of increase, 161 per cent, although this was an actual increase of only 1,161 tons. The greatest actual increase was recorded in Ohio, a gain of 10,037 tons. The number of plants in Ohio, however, increased only 1—from 31 in 1917 to 32 in 1918. All the States except Arkansas, California, Maine, Minnesota, New Jersey, Oregon, Virginia, West Virginia, and Wisconsin showed increases in value of output in 1918. In all these nine States the percentage of decrease in quantity was much greater than the percentage of decrease in value.

The three leading States in the quantity of lime sold in 1918 were the same as in 1917—Pennsylvania, Ohio, and Virginia. The next four show some differences, however. Missouri was fourth, West Virginia fifth, Michigan sixth, and Massachusetts seventh. In 1917 West Virginia was fourth, Missouri fifth, Wisconsin sixth, and Michigan seventh. Wisconsin dropped from sixth to ninth place in 1918. Seven States exceeded the million-dollar mark in value of output in 1918, compared with six in 1917. Pennsylvania exceeded $6,000,000. Ohio $4,000,000, and Virginia $1,600,000.

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Lime sold in the United States in 1917.

State or Territory.	Rank of State by quantity.	Quantity (short tons).	Percentage of total quantity	Value.	Rank of State by value.	Average price per ton.	Number of plants in operation.
Alabama	16	66,744	1.76	$383,211	17	$5.74	10
Arizona	23	15,856	.42	119,995	21	7.57	3
Arkansas	22	17,350	.46	117,593	23	6.78	4
California	15	78,401	2.07	597,528	13	7.62	14
Colorado	30	6,212	.16	54,676	28	8.80	4
Connecticut	17	64,389	1.70	492,678	16	7.65	5
Florida	24	9,914	.26	56,903	27	5.74	4
Hawaii	37	(a)	(a)	(a)	33	13.94	1
Idaho	27	7,228	.19	62,331	25	8.63	3
Illinois	14	83,409	2.20	501,320	15	6.00	11
Indiana	11	118,530	3.13	646,555	12	5.45	6
Iowa	25	(a)	(a)	(a)	26	6.45	2
Kentucky	40	723	.02	3,783	40	5.23	4
Maine	10	124,199	3.28	950,811	7	7.67	4
Maryland	9	133,087	3.52	694,576	11	5.22	24
Massachusetts	8	134,937	3.56	916,569	8	6.79	10
Michigan	7	135,920	3.59	892,682	16	6.57	7
Minnesota	21	18,072	.48	119,704	22	6.62	5
Missouri	5	234,936	6.21	1,435,914	4	6.11	21
Montana	31	5,281	.14	35,512	34	6.72	3
Nevada	29	(a)	(a)	(a)	30	6.41	1
New Jersey	32	5,002	.13	18,978	38	3.80	7
New Mexico	39	1,829	.05	12,327	39	6.79	3
New York	12	108,788	2.87	892,855	9	8.20	20
North Carolina	28	(a)	(a)	(a)	29	7.41	2
Ohio	2	479,856	12.67	2,975,466	2	6.20	31
Oklahoma	36	(a)	(a)	(a)	36	7.71	2
Oregon	33	4,498	.12	40,065	31	8.99	5
Pennsylvania	1	936,209	24.73	5,900,056	1	6.28	222
Porto Rico	35	3,803	.10	29,139	35	7.66	23
Rhode Island	38	(a)	(a)	(a)	37	11.02	1
South Dakota	34	4,463	.12	37,589	32	8.37	4
Tennessee	13	101,836	2.69	504,599	14	4.96	14
Texas	18	52,742	1.39	361,308	19	6.83	8
Utah	26	9,130	.24	63,574	24	6.96	9
Vermont	19	46,169	1.22	364,071	18	7.89	7
Virginia	3	307,195	8.11	1,820,446	3	5.93	32
Washington	20	23,328	.62	156,553	20	6.71	7
West Virginia	4	245,569	6.49	1,268,343	5	5.16	23
Wisconsin	6	169,650	4.48	1,037,578	6	6.12	28
Wyoming	41	(a)	(a)	(a)	41	21.93	1
Undistributed	.....	31,109	.82	242,589	.....	.....	.....
	.....	3,786,364	100.00	23,807,877	.....	6.29	595

a Included in "Undistributed."

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Lime sold in the United States in 1918.

State or Territory.	Rank of State by quantity.	Quantity (short tons).	Percentage of total quantity.	Value.	Rank of State by value.	Average price per ton.	Number of plants in operation.
Alabama	17	49,209	1.54	$439,366	16	$8.93	9
Arizona	21	11,212	.35	126,390	20	11.27	3
Arkansas	24	8,320	.26	62,250	25	7.48	3
California	15	55,588	1.73	558,058	14	10.04	11
Colorado	26	6,077	.19	61,476	26	10.12	4
Connecticut	16	(a)	(a)	(a)	22	7.90	6
Florida	31	(a)	(a)	(a)	27	13.58	1
Hawaii	34	(a)	(a)	(a)	32	11.25	1
Idaho	39	(a)	(a)	(a)	36	10.72	2
Illinois	14	64,672	2.02	535,090	15	8.27	11
Indiana	8	116,321	3.63	865,597	10	7.44	8
Iowa	23	(a)	(a)	(a)	24	7.65	2
Kansas	40	(a)	(a)	(a)	40	7.00	1
Kentucky	38	1,884	.06	14,925	38	7.92	3
Maine	13	83,034	2.59	906,179	9	10.91	4
Maryland	10	106,737	3.33	808,766	11	7.58	19
Massachusetts	7	123,697	3.86	1,030,929	7	8.33	11
Michigan	6	134,813	4.21	1,186,007	6	8.80	7
Minnesota	22	10,792	.34	86,882	21	8.05	5
Missouri	4	201,737	6.29	1,721,800	3	8.53	20
Montana	29	(a)	(a)	(a)	33	5.32	2
Nevada	28	(a)	(a)	(a)	30	7.51	1
New Jersey	37	2,208	.07	12,268	39	5.56	3
New Mexico	35	(a)	(a)	(a)	37	7.67	2
New York	12	87,127	2.71	913,366	8	10.48	15
North Carolina	27	(a)	(a)	(a)	28	9.75	1
Ohio	2	489,893	15.28	4,640,536	2	9.47	32
Oklahoma	33	(a)	(a)	(a)	35	9.00	2
Oregon	36	2,257	.07	26,884	34	11.91	4
Pennsylvania	1	801,834	25.01	6,654,407	1	8.30	162
Porto Rico	32	3,973	.12	44,047	29	11.09	27
Rhode Island	41	(a)	(a)	(a)	41	12.30	1
South Dakota	30	4,772	.15	40,490	31	8.48	4
Tennessee	11	106,527	3.32	682,450	13	6.41	17
Texas	18	45,206	1.41	363,022	18	8.03	8
Utah	25	7,844	.24	67,642	23	8.62	8
Vermont	19	35,728	1.11	382,363	17	10.70	7
Virginia	3	249,990	7.80	1,629,567	4	6.52	27
Washington	20	22,118	.69	226,104	19	10.22	6
West Virginia	5	167,901	5.24	1,194,610	5	7.11	10
Wisconsin	9	109,303	3.41	740,700	12	6.78	25
Wyoming	42	(a)	(a)	(a)	42	18.75	1
Undistributed	.....	95,242	2.97	786,738	.....	.....	.....
	.....	3,206,016	100.00	26,808,909	.....	8.36	496

a Included in "Undistributed."

CONDITIONS IN COMMERCIAL DISTRICTS.

The National Lime Association, through the special committee on constitution and by-laws, appointed in August, 1919, revised the division of the United States into 14 commercial districts. The 14 districts now recognized are as follows (Pl. VI):

1. Maine, New Hampshire, Vermont, Massachusetts, Connecticut, Rhode Island, and that portion of New York tributary to New York City.
2. Eastern Pennsylvania, New Jersey, eastern portion of West Virginia, Delaware, and Maryland.
3. Western Pennsylvania, western New York, and western West Virginia.
4. Virginia, North Carolina, and South Carolina.
5. Ohio.
6. Michigan.
7. Illinois, Indiana, and eastern Missouri.
8. Wisconsin.
9. North Dakota, South Dakota, Minnesota, and Iowa.
10. Kentucky and Tennessee.
11. Mississippi, Alabama, Georgia, and Florida.
12. Western Missouri, Nebraska, Kansas, Oklahoma, Arkansas, Louisiana, Wyoming, and Colorado.
13. Texas and New Mexico.
14. Territory west of the Rocky Mountains.

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Lime sold in the United States in 1918 and 1917, by districts.

District.	Hydrated lime, 1918.		Total lime, 1918.		Total lime, 1917.		Increase or decrease in 1918 (per cent) (total lime).		Average price per ton, total lime.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity.	Value.	1918	1917
1. Maine, Vermont, Massachusetts, Connecticut, Rhode Island, eastern New York	26,586	$241,152	380,311	$3,625,047	474,791	$3,602,621	−20	+ 0.6	$9.53	$7.59
2. Eastern Pennsylvania, New Jersey, Maryland, eastern West Virginia	185,067	1,535,322	871,890	7,294,192	1,083,123	6,662,031	−20	+ 9	8.37	6.15
3. Western Pennsylvania, western New York, western West Virginia	21,205	176,081	211,332	1,420,601	242,427	1,256,322	−13	+13	6.72	5.18
4. Virginia, North Carolina	(a)	(a)	b 249,990	b 1,629,567	b 307,195	b 1,820,446	−19	−11	6.59	5.96
5. Ohio	234,902	2,060,369	489,893	4,640,536	479,856	2,975,466	+ 2	+56	9.47	6.20
6. Michigan	(a)	(a)	134,813	1,186,007	135,920	892,682	− 1	+33	8.80	6.57
7. Illinois, Indiana, eastern Missouri	56,020	503,449	322,596	2,573,650	366,795	2,110,789	−12	+22	7.98	5.75
8. Wisconsin	16,883	117,754	109,303	740,700	169,650	1,037,578	−36	−29	6.78	6.12
9. South Dakota, Minnesota, Iowa	(a)	(a)	(a)	(a)	(a)	(a)	−24	−11	7.95	6.83
10. Kentucky, Tennessee	19,268	135,612	108,411	697,375	102,559	508,382	+ 6	+37	6.43	4.96
11. Alabama, Florida	c 6,327	c 61,271	c 49,209	c 439,366	c 66,744	c 383,211	−30	+14	9.31	5.74
12. Western Missouri, Kansas, Oklahoma, Arkansas, Wyoming, Colorado	(a)	(a)	77,838	701,640	97,162	673,056	−20	+ 4	9.01	6.93
13. Texas and New Mexico	15,594	129,044	47,496	380,596	54,571	373,635	−13	+ 2	8.01	6.85
14. Western Montana, Idaho, Utah, Arizona, Nevada, Washington, Oregon, California	10,725	120,809	111,729	1,095,172	(a)	(a)			9.80	7.45
Undistributed d	27,639	261,650	41,205	384,460	205,571	1,511,658				
	620,216	5,342,513	3,206,016	26,808,909	3,786,364	23,807,877	−15.3	+12.6	8.36	6.29

a Included in "Undistributed."
b Virginia only; North Carolina included in "Undistributed."
c Alabama only; Florida included in "Undistributed."
d Hawaii and Porto Rico included in "Undistributed."

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District No. 1, which includes all the New England States and part of New York, produced 380,311 tons of lime, valued at $3,625,047 in 1918, a decrease of about 20 per cent in quantity and an increase of 0.6 per cent in value, compared with 1917. The average price per ton in 1918 was $9.53—an increase of $1.94 over the price for 1917. The quantity of hydrated lime produced amounted to 26,586 tons. Reduced production in this district seems to have been due principally to lack of fuel and war restrictions on building. About 50 per cent of New England's production in normal times is used in the building industries. The demand for chemical (and "other") lime was better than usual. A large portion, 37 per cent, of the lime produced in this district is used by paper mills.

The production of district No. 2 (eastern Pennsylvania, New Jersey, eastern West Virginia, and Maryland) amounted to 871,890 tons, valued at $7,294,192. Of this, 185,067, tons valued at $1,535,322, was hydrated lime. The total quantity showed a decrease of about 20 per cent compared with 1917, although the value showed an increase of 9 per cent. The average price per ton rose from $6.15 in 1917 to $8.37 in 1918. Manufacturers in this district reported very good demand. In Pennsylvania two large companies reported that the demand as a whole was as good or better than normal, although the demand for building lime was much less.

The total production in district No. 3 (western Pennsylvania, western New York, and western West Virginia) was 211,332 tons, valued at $1,420,601—a decrease in quantity of 13 per cent and an increase in value of 13 per cent. The average price per ton was $6.72, an advance of $1.54 over the price for 1917. The quantity of hydrated lime produced amounted to 21,205 short tons. Industrial conditions were about the same as for district No. 2. In New York the high price of coal was one of the greatest difficulties encountered. The output of the recently built plant of the Kelley Island Lime & Transport Co., at Buffalo, N. Y., is included in the production of this district.

In district No. 4 (Virginia, North Carolina, and South Carolina) there was a decrease in quantity of about 19 per cent and a decrease in value of 11 per cent. Only one company operated in North Carolina and none in South Carolina. The average price per ton increased from $5.96 in 1917 to $6.59 in 1918. The quantity of hydrated lime produced increased somewhat over the quantity in 1917. The decreased output of lime was more likely due to increased costs and lack of fuel than to poor demand. Several manufacturers from Virginia reported good demand for agricultural lime and excellent demand for chemical and "other" lime. About half of the lime from this district was used by chemical works and manufacturing plants.

Production in Ohio, the fifth district, amounted to 489,893 tons, valued at $4,640,536. This was an increase in quantity of 2 per cent and an increase in value of 56 per cent over the production for 1917. The average price per ton advanced from $6.20 in 1917 to $9.47 in 1918. Hydrated lime amounted to 234,902 tons, valued at $2,060,369. The increase in quantity was due mainly to "other" lime and partly to agricultural lime, which offset the large decrease in building lime. Producers in Ohio (including some of the largest lime producers in the United States) seemed generally very optimistic about conditions and reported good demand with high prices and correspondingly high costs.

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The State of Michigan constitutes the sixth district. Here production amounted to 134,813 tons—a decrease of 1 per cent compared with production in 1917. In value, however, production showed an increase of 33 per cent. The average price per ton ($8.80) was an increase of $2.23 over the price in 1917. There was a large demand of lime for chemical uses in this State, but the demand for building lime declined to almost nothing.

District No. 7 (Illinois, Indiana, and eastern Missouri) reported a production of 322,596 tons—a decrease of 12 per cent compared with the production of the preceding year. The value, on the other hand, increased 22 per cent. This district, like many others, showed an increased demand for chemical and "other" lime, but a greatly decreased demand for building lime. Lime for use in steel plants also had an increased demand. Several new developments were reported from this district. At Logansport, Ind., a lime plant was put into operation by the Logansport Lime & Stone Co., and at Salem the Louisville Lime & Cement Co. was succeeded by the Hoosier Lime Co. In Missouri the Bluff City Lime & Cement Co. started operations at the quarry of the Star Lime Co., at Hannibal, which had not been in operation for some time. One plant in Illinois that was idle in 1917 resumed operations.

The eighth district (Wisconsin) produced 109,303 tons of lime in 1918, valued at $740,700—a decrease in quantity of 36 per cent and in value of 29 per cent. This was the greatest decrease in either quantity or value reported from any one of the 14 districts. This unusually great decrease was due to the fact that practically all of Wisconsin's lime is used for building purposes. The average price per ton, $6.78, represented an advance of only 66 cents over the price for 1917.

The ninth district comprises North Dakota, South Dakota, Minnesota, and Iowa. North Dakota produces no lime. The production in this district showed a decrease of 24 per cent, compared with the total production for 1917. In value there was a decrease of 11 per cent. The average price per ton advanced from $6.83 in 1917 to $7.95 in 1918. The total production of this district amounted to less than 25,000 tons. The demand for lime for paper mills and tanneries was reported as very good. Demand for building lime decreased greatly.

District No. 10 (Kentucky and Tennessee) produced 108,411 tons of lime, valued at $697,375, an increase of 6 per cent in quantity and of 37 per cent in value. This district and the fifth district were the only ones showing an increase in quantity in 1918. The average price per ton increased from $4.96 to $6.43. The demand for chemical and "other" lime, especially for use in munitions plants, was reported as very good. There was a decreased demand for lime for sugar factories. The plants of the Wheeler Lime Manufacturing Co., near Nashville, the Inter-State Lime Corporation, at Bristol, and the Clinchfield Portland Cement Corporation, at Kingsport, were new developments in Tennessee in 1918.

District No. 11 includes Mississippi, Alabama, Georgia, and Florida, but only two of these States, Alabama and Florida, were producers. The quantity of lime showed a decrease of about 30 per cent compared with 1917, whereas the value showed an increase of about 14 per cent. The average price per ton increased from $5.74 in 1917

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to $9.31 in 1918. Shortage of labor, cars, and fuel caused decreased production in this district.

District No. 12 includes western Missouri, Nebraska, Kansas, Oklahoma, Arkansas, Louisiana, Wyoming, and Colorado, but only six of these States are producers. The total production in 1918 amounted to only 77,838 tons, a decrease of 20 per cent compared with 1917. In value the increase was 4 per cent. The average

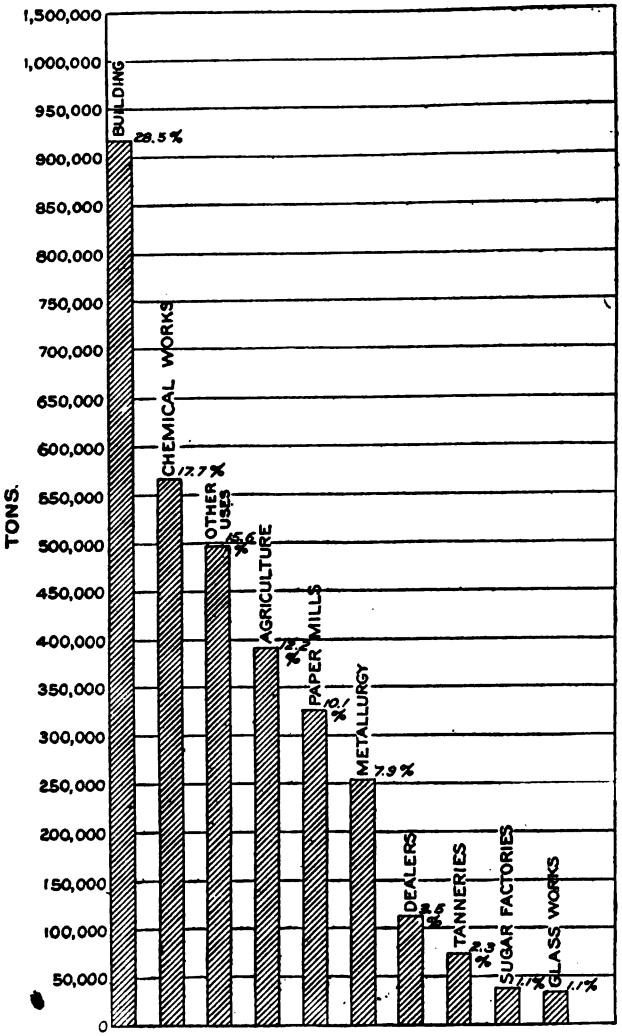

FIGURE 93.—Production of lime for specified uses in 1918.

price per ton was $9.01, an increase of $2.08 over the price for 1917. The large decrease in production was due to the decreased demand for building lime. A great percentage of the lime produced in this district is used for building purposes. In this district the plant of the Kansas City Hydrated Lime Co., Fort Scott, Bourbon County, Kans., resumed operations after having been idle several years.

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In district No. 13 (Texas and New Mexico) the production of lime decreased, but the value was about equal to the value in 1917.

The fourteenth district, including all the States west of the Rocky Mountains, produced 111,729 tons of lime in 1918. The value of the lime produced was almost the same as in 1917, although the average price per ton advanced from $7.45 to $9.80. There was

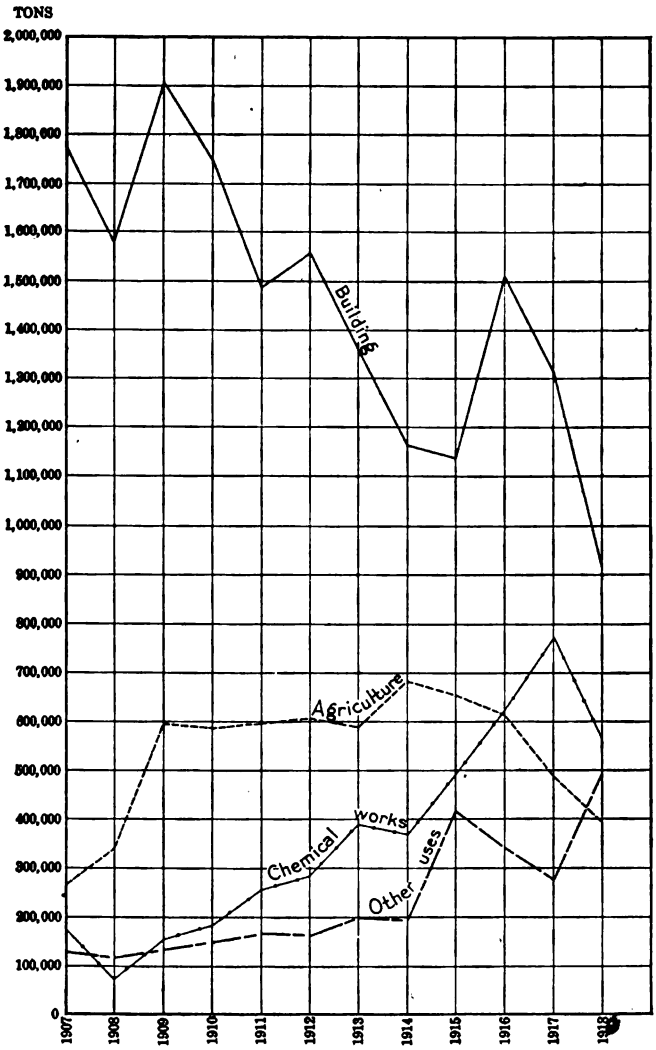

FIGURE 94.—Production of lime for principal uses, 1907–1918.

a great decrease in the lime sold to sugar factories which in normal times forms a large proportion of the total quantity of the lime produced in this district. Demand was poor for building lime, and was fair for agricultural and chemical lime. Part of the decrease in production was due to lack of shipping facilities for exporting the product.

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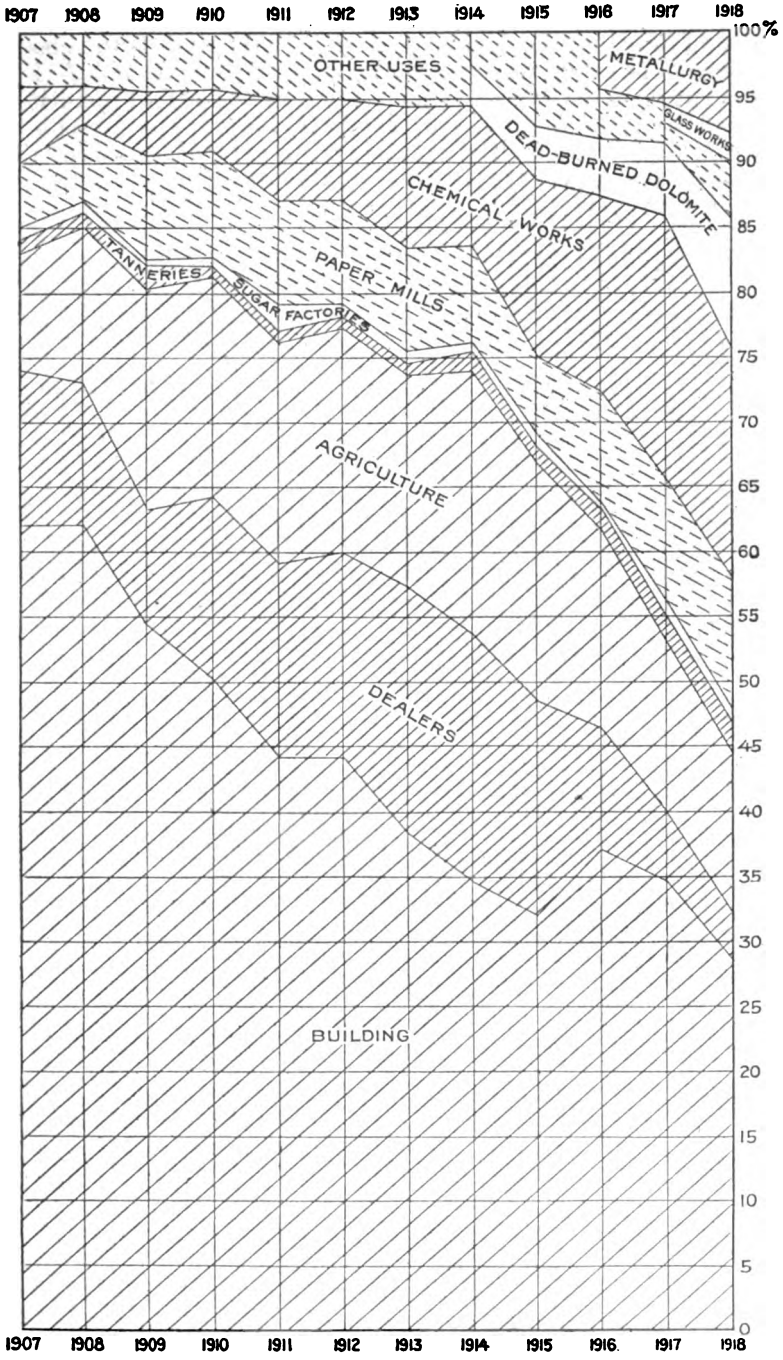

FIGURE 95.—Percentage of lime produced for different uses, by quantity, 1907–1918.

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USES.

Sales of lime in the United States in 1917 and 1918, classified according to principal uses, are shown in the following table. Figure 94 is a diagram showing the fluctuation in the actual quantities of lime sold for the four principal uses from 1907 to the present time. Figure 95 is a diagram showing what percentage of each year's total production was consumed in each of the classified uses from 1907 to the present time.

Lime sold in the United States in 1917 and 1918, by uses.

	Percentage of total quantity.	Quantity (short tons).	Value.	Average price per ton.
1917.				
Building lime	34.7	1,313,493	$8,713,845	$6.63
Chemical works	20.4	772,787	4,476,191	5.79
Paper mills	9.4	355,768	2,008,433	5.65
Glassworks	1.6	60,624	316,280	5.22
Sugar factories	1.3	47,546	381,746	8.03
Tanneries	1.8	66,629	408,976	6.14
Agriculture	12.9	488,297	2,475,731	5.07
Metallurgy	5.5	209,976	1,141,647	5.44
Dealers—uses not specified	5.1	194,028	1,245,654	6.42
Other uses [a]	7.3	277,216	2,639,374	9.52
	100.0	3,786,364	23,807,877	6.29
Hydrated lime (included in total)	.....	709,157	4,643,004	6.55
1918.				
Building lime	28.5	914,186	7,781,388	8.51
Chemical works	17.7	566,532	4,177,302	7.37
Paper mills	10.1	325,172	2,610,645	8.03
Glassworks	1.1	34,051	265,855	7.81
Sugar factories	1.1	36,494	314,748	8.62
Tanneries	2.3	74,350	637,960	8.58
Agriculture	12.2	391,047	2,698,848	6.90
Metallurgy	7.9	253,778	1,884,672	7.43
Dealers—uses not specified	3.5	111,343	960,596	8.63
Other uses [a]	15.6	499,063	5,476,895	10.97
	100.0	3,206,016	26,808,909	8.36
Percentage of increase or decrease in 1918	.....	−15.3	+12.6	.....
Hydrated lime (included in total)	.....	620,216	5,342,113	8.61
Percentage of increase or decrease of hydrated lime in 1918	.....	−12.5	+15.1	.....

[a] Includes lime for sand-lime brick, slag cement, alkali works, sheep dipping, disinfectant, manufacture of soap, cyanide plants, glue factories, purification of water, etc.

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Lime sold in the United States in 1917 and 1918, by States and uses.

1917.

State or Territory.	Building.		Metallurgy.		Chemical works.		Paper mills.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Alabama	40,336	$237,410	.....	.....	3,222	$16,503	7,660	$35,968
Arizona	13,646	104,525	(a)	(a)	(a)	(a)	.....	.....
Arkansas	12,650	88,456	.....	.....	(a)	(a)	(a)	(a)
California	17,841	147,447	3,184	$22,478	8,607	49,886	(a)	(a)
Colorado	(a)	(a)	5,284	47,520	(a)	(a)	.....	.....
Connecticut	54,176	411,722	.....	.....	(a)	(a)	.....	.....
Florida	8,354	54,366	.....	.....	.....	.....	.....	.....
Hawaii	.....	.....	.....	.....	.....	.....	.....	.....
Idaho	2,151	20,568	.....	.....	.....	.....	(a)	(a)
Illinois	39,669	243,867	.....	.....	29,689	165,703	2,915	16,974
Indiana	9,309	55,246	(a)	(a)	51,678	288,315	25,679	137,172
Iowa	(a)	(a)	(a)	(a)	.....	.....	(a)	(a)
Kentucky	98	838	.....	.....	.....	.....	.....	.....
Maine	61,542	537,135	.....	.....	(a)	(a)	46,652	328,107
Maryland	10,138	44,751	(a)	(a)	30,047	139,496	.....	.....
Massachusetts	62,222	516,944	.....	.....	25,907	167,781	(a)	(a)
Michigan	1,273	8,569	(a)	(a)	110,174	721,107	8,452	53,150
Minnesota	16,272	106,704	.....	.....	.....	.....	.....	.....
Missouri	59,986	357,519	(a)	(a)	68,051	397,473	14,576	75,428
Montana	(a)	(a)	(a)	(a)	.....	.....	.....	.....
Nevada	.....	.....	(a)	(a)	.....	.....	.....	.....
New Jersey	.....	.....	.....	.....	.....	.....	.....	.....
New Mexico	687	4,904	.....	.....	.....	.....	.....	.....
New York	14,848	101,117	(a)	(a)	9,906	73,559	29,394	201,070
North Carolina	(a)	(a)	.....	.....	.....	.....	.....	.....
Ohio	371,920	2,352,342	2,035	11,080	2,688	15,447	11,665	63,743
Oklahoma	(a)	(a)	.....	.....	.....	.....	.....	.....
Oregon	3,498	32,065	.....	.....	.....	.....	.....	.....
Pennsylvania	163,658	1,034,504	90,688	445,609	129,791	705,594	78,181	377,933
Porto Rico	670	3,359	.....	.....	.....	.....	.....	.....
Rhode Island	.....	.....	.....	.....	(a)	(a)	.....	.....
South Dakota	1,630	12,796	(a)	(a)	.....	.....	.....	.....
Tennessee	44,717	247,546	.....	.....	(a)	(a)	27,798	113,486
Texas	37,482	261,036	(a)	(a)	(a)	(a)	(a)	(a)
Utah	3,623	28,601	(a)	(a)	.....	.....	.....	.....
Vermont	11,303	92,768	(a)	(a)	8,508	70,692	18,963	140,953
Virginia	65,598	454,133	(a)	(a)	166,549	952,142	(a)	(a)
Washington	4,660	37,136	(a)	(a)	(a)	(a)	1,178	11,381
West Virginia	(a)	(a)	(a)	(a)	97,747	500,063	(a)	(a)
Wisconsin	141,374	865,773	(a)	(a)	(a)	(a)	14,880	89,132
Wyoming	(a)	(a)	.....	.....	.....	.....	.....	.....
Undistributed	38,162	249,698	108,785	614,960	30,223	212,430	67,775	363,936
	1,313,493	8,713,845	209,976	1,141,647	772,787	4,476,191	355,768	2,008,433

a Included in "Undistributed."

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Lime sold in the United States in 1917 and 1918, by States and uses—Continued.

1917.

State or Territory.	Sugar factories.		Tanneries.		Glassworks.		Agriculture.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Alabama	1,210	$7,459	(a)	(a)	.....	.....	1,791	$9,816
Arizona	.....	.....	.....	.....	.....	.....	.....	.....
Arkansas	(a)	(a)	.....	.....	.....	.....	(a)	(a)
California	33,614	272,220	(a)	(a)	.....	.....	6,196	32,447
Colorado	(a)	(a)	.....	.....	.....	.....	.....	.....
Connecticut	.....	.....	.....	.....	.....	.....	(a)	(a)
Florida	.....	.....	.....	.....	.....	.....	(a)	(a)
Hawaii	(a)	(a)	.....	.....	.....	.....	(a)	(a)
Idaho	.....	.....	.....	.....	.....	.....	(a)	(a)
Illinois	(a)	(a)	4,175	$27,679	.....	.....	(a)	(a)
Indiana	.....	.....	1,830	11,176	4,520	$25,946	2,297	12,143
Iowa	.....	.....	.....	.....	.....	.....	.....	.....
Kentucky	.....	.....	.....	.....	.....	.....	(a)	(a)
Maine	.....	.....	(a)	(a)	.....	.....	10,243	35,216
Maryland	.....	.....	(a)	(a)	.....	.....	85,633	463,081
Massachusetts	.....	.....	.....	.....	.....	.....	5,073	18,185
Michigan	.....	.....	1,681	11,738	.....	.....	(a)	(a)
Minnesota	.....	.....	.....	.....	.....	.....	.....	.....
Missouri	.....	.....	6,085	31,996	(a)	(a)	4,317	26,844
Montana	.....	.....	.....	.....	.....	.....	.....	.....
Nevada	.....	.....	.....	.....	.....	.....	.....	.....
New Jersey	.....	.....	.....	.....	.....	.....	5,002	18,978
New Mexico	.....	.....	.....	.....	.....	.....	.....	.....
New York	(a)	(a)	3,222	28,868	.....	.....	9,588	40,510
North Carolina	.....	.....	(a)	(a)	.....	.....	(a)	(a)
Ohio	.....	.....	(a)	(a)	39,934	200,634	29,997	161,225
Oklahoma	.....	.....	.....	.....	.....	.....	.....	.....
Oregon	.....	.....	.....	.....	.....	.....	.....	.....
Pennsylvania	2,078	15,603	24,236	138,305	9,954	58,707	246,608	1,218,316
Porto Rico	2,193	20,334	.....	.....	.....	.....	927	5,323
Rhode Island	.....	.....	.....	.....	.....	.....	(a)	(a)
South Dakota	.....	.....	.....	.....	.....	.....	.....	.....
Tennessee	3,900	24,800	2,905	12,178	.....	.....	1,904	9,835
Texas	1,660	11,595	.....	.....	.....	.....	(a)	(a)
Utah	(a)	(a)	(a)	(a)	.....	.....	.....	.....
Vermont	.....	.....	5,824	46,731	.....	.....	502	1,390
Virginia	(a)	(a)	2,775	13,129	.....	.....	44,335	235,568
Washington	(a)	(a)	.....	.....	.....	.....	(a)	(a)
West Virginia	.....	.....	8,484	48,771	(a)	(a)	21,999	106,892
Wisconsin	.....	.....	2,400	15,289	(a)	(a)	954	5,024
Wyoming	.....	.....	.....	.....	.....	.....	.....	.....
Undistributed	2,891	29,735	3,012	23,116	6,216	30,993	10,931	74,938
	47,546	381,746	66,629	408,976	60,624	316,280	488,297	2,475,731

a Included in "Undistributed."

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Lime sold in the United States in 1917 and 1918, by States and uses—Continued.

1917.

State or Territory.	Dealers.		Other uses.		Total.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Alabama	11,290	$69,879	(a)	(a)	66,744	$383,211
Arizona					15,856	119,995
Arkansas	(a)	(a)			17,350	117,593
California	5,751	46,903	2,418	$19,656	78,401	597,528
Colorado	(a)	(a)			6,212	54,676
Connecticut					64,389	492,678
Florida			(a)	(a)	9,914	56,903
Hawaii					(a)	(a)
Idaho					7,228	62,331
Illinois	(a)	(a)	(a)	(a)	83,409	501,320
Indiana	(a)	(a)	7,869	39,802	118,530	646,555
Iowa					(a)	(a)
Kentucky	(a)	(a)	(a)	(a)	723	3,783
Maine					124,199	950,811
Maryland					133,087	694,576
Massachusetts			(a)	(a)	134,937	916,569
Michigan	(a)	(a)	(a)	(a)	135,920	892,682
Minnesota			(a)	(a)	18,072	119,704
Missouri	63,537	452,491	4,004	21,963	234,936	1,435,914
Montana	(a)	(a)			5,281	35,512
Nevada			(a)	(a)	(a)	(a)
New Jersey					5,002	18,978
New Mexico			(a)	(a)	1,829	12,327
New York	2,648	20,030	29,387	347,463	108,788	892,855
North Carolina					(a)	(a)
Ohio	6,334	40,021	15,257	130,814	479,856	2,975,466
Oklahoma	(a)	(a)			(a)	(a)
Oregon	(a)	(a)			4,498	40,065
Pennsylvania	12,057	68,306	178,958	1,837,179	936,209	5,900,056
Porto Rico			13	123	3,803	29,139
Rhode Island	(a)	(a)			(a)	(a)
South Dakota					4,463	37,589
Tennessee	10,669	53,914	3,843	15,240	101,836	504,599
Texas	3,172	22,227	(a)	(a)	52,742	361,308
Utah	(a)	(a)	(a)	(a)	9,130	63,574
Vermont	(a)	(a)	(a)	(a)	46,169	364,071
Virginia	11,334	67,073			307,195	1,820,446
Washington	8,969	53,538	(a)	(a)	23,328	156,553
West Virginia	12,730	62,229	16,414	99,596	245,569	1,268,343
Wisconsin	7,790	48,855			169,650	1,037,578
Wyoming					(a)	(a)
Undistributed	37,747	240,188	19,053	127,538	31,109	242,589
	194,028	1,245,654	277,216	2,639,374	3,786,364	23,807,877

a Included in "Undistributed."

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Lime sold in the United States in 1917 and 1918, by States and uses—Continued.

1918.

State.	Building.		Metallurgy.		Chemical works.		Paper mills.	
	Quantity (short tons.)	Value.	Quantity (short tons).	Value	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Alabama	27,770	$257,070	6,877	$56,488	(a)	(a)	4,663	$38,308
Arizona	6,919	79,197	(a)	(a)	(a)	(a)		
Arkansas	6,620	50,600			(a)	(a)	(a)	(a)
California	14,016	140,217	(a)	(a)	9,225	$93,417	(a)	(a)
Colorado	2,099	21,400	(a)	(a)	(a)	(a)		
Connecticut	(a)	(a)			(a)	(a)	(a)	(a)
Florida	(a)	(a)						
Hawaii	(a)	(a)						
Idaho	(a)	(a)					(a)	(a)
Illinois	26,119	214,222			10,542	87,108	6,834	53,731
Indiana	8,008	60,366	2,454	19,098	36,187	260,505	22,320	173,551
Iowa	(a)	(a)	(a)	(a)				
Kansas	(a)	(a)						
Kentucky	(a)	(a)						
Maine	32,521	422,444	(a)	(a)	(a)	(a)	(a)	(a)
Maryland	5,638	45,155	(a)	(a)	4,546	34,752	(a)	(a)
Massachusetts	36,823	328,398	(a)	(a)	18,028	147,075	57,930	470,516
Michigan	(a)	(a)	(a)	(a)	110,028	975,825	(a)	(a)
Minnesota	10,325	83,146			(a)	(a)		
Missouri	42,047	377,334	35,760	279,432	43,881	357,646	7,786	64,542
Montana	(a)	(a)	(a)	(a)	(a)	(a)		
Nevada	(a)	(a)	(a)	(a)	(a)	(a)		
New Jersey								
New Mexico	(a)	(a)			(a)	(a)		
New York	17,264	147,580	9,122	91,781	3,169	32,000	24,381	227,996
North Carolina	(a)	(a)	(a)	(a)			(a)	(a)
Ohio	254,318	2,228,153	3,507	26,860	(a)	(a)	11,875	90,812
Oklahoma	(a)	(a)						
Oregon	2,207	26,334	(a)	(a)				
Pennsylvania	126,432	1,020,744	87,327	599,136	84,562	595,152	77,512	527,313
Porto Rico	1,118	9,535						
Rhode Island	(a)	(a)			(a)	(a)		
South Dakota	(a)	(a)			(a)	(a)		
Tennessee	36,685	248,609			24,548	146,520	9,821	60,868
Texas	30,938	253,251	2,445	19,505	437	3,470	(a)	(a)
Utah	3,361	34,022	(a)	(a)				
Vermont	4,142	50,818	(a)	(a)	10,907	122,786	4,479	45,679
Virginia	38,339	324,938	15,453	121,191	136,735	764,206	8,726	64,554
Washington	5,734	58,447	3,879	34,778	(a)	(a)	(a)	(a)
West Virginia	14,408	106,846	55,042	388,625	(a)	(a)	(a)	(a)
Wisconsin	90,442	610,277			197	1,567	14,400	98,860
Wyoming	(a)	(a)						
Undistributed	69,893	582,285	31,912	247,778	73,540	555,273	74,445	693,915
	914,186	7,781,388	253,778	1,884,672	566,532	4,177,302	325,172	2,610,645

a Included in "Undistributed."

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Lime sold in the United States in 1917 and 1918, by States and uses—Continued.

1918.

State.	Sugar factories.		Tanneries.		Glass works.		Agriculture.	
	Quantity (short tons).	Value.	Quantity (short tons.)	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Alabama	(a)	(a)	(a)	(a)			1,947	$17,436
Arizona	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Arkansas	(a)	(a)					(a)	(a)
California	17,254	$144,450	(a)	(a)			850	8,304
Colorado								
Connecticut							(a)	(a)
Florida								
Hawaii	(a)	(a)						
Idaho								
Illinois	(a)	(a)	(a)	(a)				
Indiana			2,179	$17,559	3,006	$22,699	1,303	6,122
Iowa								
Kansas								
Kentucky							(a)	(a)
Maine	(a)	(a)	(a)	(a)			8,017	46,168
Maryland							68,807	534,852
Massachusetts			4,648	23,163			3,089	35,450
Michigan			2,968	26,186			(a)	(a)
Minnesota							(a)	(a)
Missouri	(a)	(a)	(a)	(a)	616	5,963	193	1,706
Montana								
Nevada	(a)	(a)						
New Jersey							2,208	12,268
New Mexico							(a)	(a)
New York	(a)	(a)	3,187	40,836	(a)	(a)	5,931	27,868
North Carolina			(a)	(a)				
Ohio			(a)	(a)	28,633	225,652	40,001	275,561
Oklahoma								
Oregon								
Pennsylvania	2,964	23,560	26,006	196,791	1,281	7,675	200,073	1,343,636
Porto Rico	1,997	27,961					823	6,329
Rhode Island							(a)	(a)
South Dakota								
Tennessee	8,690	66,071	(a)	(a)			3,311	15,333
Texas	1,921	13,787	(a)	(a)			(a)	(a)
Utah							(a)	(a)
Vermont			9,810	106,583			2,201	8,288
Virginia	(a)	(a)	3,988	30,516			34,444	232,204
Washington	(a)	(a)					(a)	(a)
West Virginia			(a)	(a)			16,053	116,554
Wisconsin			2,749	20,386	(a)	(a)	241	502
Wyoming								
Undistributed	3,668	38,919	18,815	175,940	515	3,866	1,555	10,267
	36,494	314,748	74,350	637,960	34,051	265,855	391,047	2,698,848

a Included in "Undistributed."

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Lime sold in the United States in 1917 and 1918, by States and uses—Continued.

1918.

State.	Dealers.		Other uses.		Total.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Alabama	(a)	(a)	(a)	(a)	49,209	$439,366
Arizona			(a)	(a)	11,212	126,390
Arkansas					8,320	62,250
California	7,018	$87,450	3,557	$36,588	55,588	558,058
Colorado			(a)	(a)	6,077	61,476
Connecticut					(a)	(a)
Florida					(a)	(a)
Hawaii					(a)	(a)
Idaho					(a)	(a)
Illinois	(a)	(a)	13,481	111,497	64,672	535,090
Indiana	8,093	64,695	32,771	241,002	116,321	865,597
Iowa					(a)	(a)
Kansas					(a)	(a)
Kentucky	(a)	(a)			1,884	14,925
Maine			(a)	(a)	83,034	906,179
Maryland			13,584	101,811	106,737	808,766
Massachusetts			(a)	(a)	123,697	1,030,929
Michigan	(a)	(a)	(a)	(a)	134,813	1,186,007
Minnesota			(a)	(a)	10,792	86,882
Missouri	39,473	366,112	30,096	249,900	201,737	1,721,800
Montana	(a)	(a)	(a)	(a)	(a)	(a)
Nevada					(a)	(a)
New Jersey					2,208	12,268
New Mexico			(a)	(a)	(a)	(a)
New York	(a)	(a)	23,460	338,941	87,127	913,366
North Carolina					(a)	(a)
Ohio	(a)	(a)	144,415	1,736,008	489,893	4,640,536
Oklahoma					(a)	(a)
Oregon					2,257	26,884
Pennsylvania	10,242	69,422	185,435	2,270,978	801,834	6,654,407
Porto Rico			35	222	3,973	44,047
Rhode Island					(a)	(a)
South Dakota					4,772	40,490
Tennessee	(a)	(a)	20,200	124,746	106,527	682,450
Texas			7,868	61,381	45,206	363,022
Utah			(a)	(a)	7,844	67,642
Vermont	(a)	(a)	3,358	35,965	35,728	382,363
Virginia	(a)	(a)	9,610	70,198	249,990	1,629,567
Washington	(a)	(a)	2,817	26,952	22,118	226,104
West Virginia	(a)	(a)			167,901	1,194,610
Wisconsin			814	5,888	109,303	740,700
Wyoming					(a)	(a)
Undistributed	46,517	372,917	7,562	64,818	95,242	786,738
	111,343	960,596	499,063	5,476,895	3,206,016	26,808,909

a Included in "Undistributed."

Lime for all uses showed a decrease in 1918 except that used in tanning, metallurgy, and for miscellaneous or "other" uses. Building lime showed the greatest decrease in quantity sold. In this the figures bear out the statements of the manufacturers that the demand for building lime was greatly reduced owing to war restrictions. On the other hand, "other uses" showed an increase in quantity of 80 per cent. This division includes lime used in many industries greatly stimulated by the war demand, such as open-hearth steel furnaces, which use dead-burned dolomite as a refractory, and alkali and other works.

The greatest apparent decrease, about 23 per cent, was in the value of the lime sold to dealers, but some of this apparent decrease was in lime otherwise reported according to its ultimate use. The greatest increase in value was in lime sold for "other uses"—an increase of 108 per cent.

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In 1918 Missouri, New York, and Pennsylvania supplied lime for all the uses listed, and Alabama, California, Indiana, Ohio, and Virginia for all but one of the uses. In 1917 Pennsylvania alone supplied lime for all the specified uses. This change was probably due in part to the fact that manufacturers were better able in 1918 to give information as to the uses for which their lime was sold and in part to the further fact that the decrease in demand for building lime compelled manufacturers to look to other industries in order to dispose of their product.

BUILDING.

Lime for building purposes showed a decrease of almost 400,000 tons, or about 30 per cent, in 1918. The quantities of building lime sold in each year have fluctuated considerably since 1907. The largest quantity reported for this use for any one year since 1907 was in 1909, when 1,906,146 tons were sold. Since 1916 the quantity sold yearly has on the whole decreased rapidly, although a considerable recovery was made in 1916. In 1917 the output of building lime represented 35 per cent of the total lime, but in 1918 it represented less than 29 per cent, and the value of building lime decreased about 11 per cent in 1918, compared with 1917. The average price per ton rose from $6.63 in 1917 to $8.51 in 1918—an advance of $1.88. In value building lime represented about 29 per cent of the total value.

It is needless to state that a recovery from this marked decrease is to be expected as soon as return to normal conditions removes the obstacles to building, and that the production of lime for building should increase steadily for at least a few years. This increase should be intensified by the increasing attention now being given to lime by producers, architects, and builders. As shown in figures 94 and 95, however, lime for building has been of decreasing importance in the lime industry for several years, and it is likely to be equaled or surpassed by that used in the combined chemical and manufacturing industries in the future, as it has been during the war.

Every State, with the exception of New York, Porto Rico, Rhode Island, and Washington, showed a decrease in the quantity of building lime sold in 1918. Ten States, however, showed an increase in value.

Manufacturers from all over the country reported the demand for building lime greatly decreased in 1918—a decrease due in large part to the war restrictions on building. Instability in business conditions caused individuals and communities to delay their building projects until a more favorable year. On the other hand, it is doubtful if a normal demand could have been met by the producers, who were greatly handicapped by lack of facilities. Ohio again led in the production of building lime, with Pennsylvania second, Wisconsin third, and Missouri fourth. Florida, Kansas, Oklahoma, and Wyoming were the only States whose total outputs went for building. These four States are small producers. The following table indicates the different ways in which building lime was used by consumers.

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Building lime sold in 1918, classified by uses according to reports of the manufacturers.

Use.	Hydrated lime.		Quick lime.		Total.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Plaster	178,811	$1,611,913	109,733	$888,214	288,544	$2,500,127
Mortar	32,219	271,685	59,004	471,484	91,223	743,169
Mortar and plaster	42,697	359,762	143,986	1,223,366	186,683	1,583,128
Unspecified	58,872	556,717	288,864	2,398,247	[a] 347,736	[a] 2,954,964
	312,599	2,800,077	601,587	4,981,311	914,186	7,781,388

[a] Includes 2,647 tons of lime, valued at $21,797, reported as sold for use in concrete, and 974 tons, valued at $6,096, reported as sold for use in gypsum products.

METALLURGY.

The lime used in metallurgy in 1918 amounted to 253,778 tons—an increase of 21 per cent over the quantity so used in 1917. The value of this lime was $1,884,672. In 1917 lime for metallurgy represented 5.5 per cent of the total production of lime; in 1918 it represented 7.9 per cent. The unusual increase in the production of this class of lime is easily accounted for by the greatly increased activity in the iron and steel industries because of the war, although part of the increase in production was probably due to the fact that some lime sold for metallurgic uses has been reported under "Chemicals" in previous years. Twenty-four States sold lime for metallurgy. Pennsylvania was the leading State, with West Virginia second and Missouri third. In the Rocky Mountain States and the Southwestern States a larger proportion of the total lime was sold for metallurgy than in any other section of the United States. More than half of the product from Colorado and Utah went for metallurgy. About one-fifth of the quantity of lime produced in each of these States—Arizona, Nevada, Missouri, and Washington—was used for metallurgy. In the other States less than 15 per cent of each State's total production was used in metallurgy. The average price per ton of this class of lime advanced from $5.44 in 1917 to $7.43 in 1918. The price in 1918 was 87 per cent higher than in 1916.

The following table shows that at least 51 per cent of the quantity of lime sold for metallurgic purposes in 1918 was used as blast-furnace flux and at least 18 per cent for the manufacture of steel. Much smaller quantities were used as smelter flux and for the manufacture of aluminum and brass.

Lime sold for metallurgic purposes in 1918, by uses.

	Quantity (short tons).	Value.
Blast-furnace flux	128,523	$903,574
Smelter flux	14,724	124,779
Manufacture of steel	44,544	342,917
Manufacture of aluminum and brass	18,292	140,393
Unspecified [a]	47,695	373,009
	253,778	1,884,672

[a] Includes some lime sold for metal pickling, and to smelters and furnaces for uses unspecified.

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CHEMICAL WORKS.

Reports from a large number of manufacturers concerning trade conditions spoke of unusually good demands for chemical lime. It would therefore be expected that the output of chemical lime in 1918 would be much greater than in 1917. Only 566,532 short tons were reported as used in chemical works, however—an apparent decrease of 27 per cent from the quantity reported in 1917, and a corresponding decrease in value of 6.7 per cent. This apparent decrease was due to a change in statistical classification. In 1918 the Geological Survey for the first time added to the blanks sent out to the producers an itemized list of uses for lime included under the general heading "other uses." This caused producers to put in this section lime which they had in previous years considered as chemical lime, and accounts for the marked increase in lime for "other uses," which more than offsets the recorded decrease in lime for chemical uses. Figure 94 shows that from 1908 to 1917, inclusive, the quantity of lime sold yearly for chemical works has increased rapidly, except in the year 1914, when a slight decrease was noted. There was a sharp decrease in 1918, but the combined quantities of chemical and "other" lime show a substantial increase.

The average price per ton of chemical lime in 1918 was $7.37—an increase of 27 per cent over the price for 1917, and of 99 per cent over the price for 1916. Virginia, Michigan, Pennsylvania, and West Virginia, in the order named, were the greatest producers of chemical lime in 1918. Michigan's output of chemical lime was 82 per cent of its total output. South Dakota, Nevada, Vermont, Indiana, Virginia, and West Virginia were other States in which the production of chemical lime was a large percentage of the total output.

Lime reported as sold to chemical manufacturers in 1918.

Use.	Quantity (short tons).	Value.
Alkali works	145,031	$768,570
Potash salts	176	1,409
Ammonia works	13,975	99,831
Explosives (kind unspecified)	23,735	173,129
Nitrates and glycerin	2,059	12,468
Guncotton preparation and gelatin	10,755	88,784
Acids	38,388	298,660
Cyaniding	12,512	118,274
Calcium carbide	87,434	785,912
Alcohol:		
Dehydration and manufacture of	1,535	10,638
Wood distillation	13,986	121,678
Bleaching works	37,905	306,726
Phenol	25,002	196,463
Salt refining	1,791	13,388
Coal and water gas purification	171	1,959
Coke-oven by-products	24,451	174,437
Gas-plant by-products	2,371	19,309
Undistributed [a]	4,481	32,966
Unspecified	120,774	952,701
	566,532	4,177,302

[a] Includes lime sold for use in manufacture of calcium acetate, aluminum hydrate, barium products and precipitated calcium carbonate.

The above table shows the chemical uses for which manufacturers reported their lime sold in 1918. About 26 per cent of the chemical lime was used by alkali works. The manufacture of calcium carbide

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consumed about 15 per cent and the manufacture of acids about 7 per cent. The use in bleaching also amounted to about 7 per cent of the total quantity. Other chemical uses required smaller quantities, although the manufacture of phenol, coke-oven by-products, alcohol, and explosives were important.

PAPER MILLS.

The quantity of lime sold to paper mills amounted to 325,172 short tons in 1918, 9 per cent less than in 1917, but its value, $2,610,645, was 30 per cent more than in 1917. The quantity of lime sold to paper mills has remained fairly constant since 1907, with the exception of the years 1914 and 1915, when there were decided decreases. The average price per ton advanced to $8.03 in 1918—an increase of $2.38 over the price for 1917.

New England was the leading district in production of lime for paper mills, supplying 34 per cent of all the lime so used. Pennsylvania produced the greatest quantity in any single State, although lime for use in paper mills amounted to less than 10 per cent of its total production. Indiana, New York, and Wisconsin were also large producers of this class of lime.

According to data furnished by the lime manufacturers the following table shows how much lime was used for each of the paper processes. It will be noted that at least 46 per cent of the total quantity of lime for paper manufacture was used in the soda process, and that about 27 per cent was used in the sulphite process. Smaller quantities were used in the sulphate, strawboard, and rag processes.

Lime sold to paper mills in 1917 and 1918.

Manufacturing process.	1917		1918	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Soda	171,865	$994,417	149,443	$1,229,579
Sulphite	77,020	422,026	88,631	726,610
Sulphate	28,154	172,635	34,515	260,726
Strawboard	9,918	55,149	19,058	146,335
Rag	(a)	(a)	14,649	115,293
Unspecified	68,811	364,206	18,876	132,112
	355,768	2,008,433	325,172	2,610,645

a Included in "Unspecified."

In addition to these quantities of burned lime 101,305 short tons of raw limestone was sold to paper mills in 1917 and 100,247 short tons in 1918.

SUGAR FACTORIES.

The lime used in sugar factories in 1918 amounted to 36,494 tons in quantity and $314,748 in value. This was a decrease of 23 per cent in quantity and 18 per cent in value compared with the consumption in 1917. The quantity of lime used in sugar factories in 1917 was the greatest recorded since 1907.

The lime used in the sugar industry in the United States varies more in quantity than in any of the other uses classified here. In 1916 lime for this use showed a decrease of 36 per cent in quantity

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and in 1917 an increase of 117 per cent. The average price per ton, $8.62, only advanced 59 cents beyond the price for 1917. Heretofore lime for use in sugar factories has had an average price per ton far above the normal price for the other uses, but in 1918 the average price per ton was only slightly above the price for all uses—$8.36.

Lime for use in sugar factories was burned in 14 States and in Hawaii and Porto Rico. California, as usual, was by far the greatest producer, its production, 17,254 tons, being 47 per cent of the total quantity consumed in the industry. Tennessee was also a large producer. In Hawaii 90 per cent of the total quantity of lime burned was used by sugar factories, and in Porto Rico about 50 per cent.

Some Pacific coast manufacturers have heretofore shipped their lime to Hawaii for use in the sugar factories there, but in 1918 that demand could not be met, as it was impossible to get the necessary transportation between the Pacific coast and Hawaii.

Both lime and carbon dioxide are used in the sugar industry, and many sugar manufacturers therefore prefer to quarry and burn their own limestone. The relation of lime to the sugar industry is more thoroughly illustrated by the following table, which shows that both limestone and lime decreased in about equal proportions:

Limestone and lime used by sugar factories, 1915–1918.

	1915		1916		1917		1918	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Limestone	394,122	$381,038	369,028	$369,694	530,612	$666,138	435,555	$649,589
Lime	34,025	230,368	21,923	118,572	47,546	381,746	36,494	314,748
	.....	611,406	.....	488,266	.....	1,047,884	.....	964,337

TANNERIES.

Lime used by tanneries amounted to 74,350 tons, valued at $637,960—an increase in quantity of 12 per cent and in value of 56 per cent, compared with 1917. The quantity consumed in 1918 for this purpose was greater than in any other year. The average price per ton increased from $6.14 in 1917 to $8.58 in 1918. Lime used by tanneries was produced in 19 States. Pennsylvania was by far the largest producer, having an output of 26,006 tons, or 35 per cent of the total quantity of lime used by tanneries. Vermont consumed 9,810 tons for this purpose, which was 27 per cent of the total quantity of lime produced by that State.

GLASS FACTORIES.

Lime used in glass factories in 1918 amounted to 34,051 tons, valued at $265,855. This represented 1.1 per cent of the total lime produced. The consumption in 1918 was a decrease in quantity of 26,573 tons, or 44 per cent, compared with 1917. In value this class of lime showed a decrease of 16 per cent. The increase in the manufacture of optical glass was very great in 1918, but the making of optical glass represents only a very small fraction of the

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glass industry and calls annually for only a few carloads of lime, limestone, or marble, which must have a remarkably low content of iron (not more than 0.05 per cent). Many of the plants making window glass, plate glass, or bottle glass were shut down in 1918, and others were running on part time, principally because of failure to get priority orders from the Government for the shipment of coal. Ohio, Indiana, Pennsylvania, Missouri, Wisconsin, New York, and Arizona furnished the total production of lime for use in glass factories. Of this quantity Ohio furnished 28,633 tons, or about 84 per cent. Arizona and New York supplied only insignificant quantities.

The average price per ton of lime for glass works advanced from $5.22 in 1917 to $7.81 in 1918. Unburned limestome sold to glass factories amounted to 293,152 short tons, valued at $344,479, in 1917, and to 202,211 short tons, valued at $332,744, in 1918.

AGRICULTURE.

LIME AND LIMESTONE.

Twelve per cent of the total quantity of lime sold in 1918 was used for agriculture. This amounted to 391,047 tons, valued at $2,698,848, a decrease of 20 per cent in quantity compared with the output of 1917, but an increase of 9 per cent in value. This was the lowest yearly output of agricultural lime reported since 1908, the output of which had increased on the whole up to 1914, when 684,348 tons were produced. Since that time consumption for agricultural uses has declined at an increasing rate (figs. 94 and 95).

Agricultural lime was produced in 27 States and in Porto Rico in 1918. Pennsylvania led with a production of 200,073 tons, about 25 per cent of the total output of the State. The other leading States in order of production were: Maryland, Ohio, Virginia, and West Virginia. New Jersey's very small production was all used for agricultural purposes. Of Maryland's production 64 per cent was used in agriculture. The average price per ton of lime used in agriculture ($6.90) increased $1.83 over the price for 1917. Agricultural lime included 3,304 tons of lime, valued at $30,328, reported as sold for use in prepared fertilizer, and 1,989 tons valued at $6,750, sold combined with wood ashes.

Pulverized limestone for use in agriculture recovered from the slight decrease in 1917, and the quantity produced in 1918 was the largest yet recorded. The price per ton ($1.49) was 19 cents more than in 1917. The accelerated decline of agricultural burned lime in contrast to the almost steady increase of pulverized limestone during the last four years is rather discouraging to producers of burned lime. Both products have been given considerable publicity, and each possesses certain advantages. Scientific authorities have differed regarding some of these advantages, and some conclusions that were unfavorable to burned lime have been revised during the present year. The Lime Association has been calling attention to these revisions, and it will be interesting to see whether they result in a recovery from the decline in production of agricultural burned lime.

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Lime and pulverized limestone sold for use in agriculture, 1911–1918.

Year.	Lime.		Limestone.	
	Quantity (short tons).	Value.	Quantity. (short tons).	Value.
1911	596,664	$1,714,386	174,290	$205,006
1912	604,607	1,852,530	200,000	311,702
1913	590,229	1,796,566	408,627	493,718
1914	684,348	2,139,444	615,197	688,961
1915	673,260	2,163,874	810,399	893,530
1916	613,527	2,224,401	1,066,376	1,146,582
1917	488,297	2,475,731	1,040,243	1,352,397
1918	391,047	2,698,848	1,091,918	1,626,292

CALCAREOUS MARL.

The calcareous marl industry, though still supplying only a small fraction of the total quantity of agricultural lime materials, has showed a marked increase during the last three years, as appears in the following table.

Calcareous marl sold in the United States, 1916–1918.

Year.	Quantity (short tons).	Value.	Average price per ton.
1916	58,088	$144,768	$2.49
1917	73,900	165,223	2.24
1918	98,694	261,082	2.65
Percentage of increase in 1918	33.6	58.0	.....

In 1916 and 1917 the entire output was reported as used in agriculture. In 1918 78,232 tons, valued at $203,500, was sold for use in agriculture, an increase of 4,332 tons (nearly 6 per cent) in quantity and of $38,277 (23 per cent) in value. The remaining 20,462 tons, valued at $57,582, was sold for the neutralization of acid waters, for use in making prepared fertilizers, and for other uses not specified.

Of the total marl produced 57,821 short tons, valued at $148,873, or $2.57 per ton, was fresh-water marl consisting mainly of small shells of fresh-water animals. It came from ten companies—six in Virginia, reporting a total output of 39,770 short tons, valued at $100,518, and one each in Arkansas, New York, Pennsylvania, and West Virginia.

The output of fresh-water marl in 1918 increased 21 per cent in quantity and 33 per cent in value, compared with that in 1917, which was 47,914 short tons, valued at $112,075, or $2.34 a ton, produced by nine companies—three in Virginia, two in California, and one each in New York, Pennsylvania, West Virginia, and Arkansas. The operations in Virginia in 1918 were at Barber, Alleghany County; Daleville, Botetourt County; Marlbrook and Riverside, Rockbridge County; and Claremont, Surry County. Two new companies at Claremont reported that shipments would be made in 1919. The plant at Caledonia, Livingston County, N. Y., which has been in operation for many years, was burned in 1917 and operations at the deposit have not been resumed, the marl sold in 1918 being

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material on hand. A new company began operations at Cassadaga, Chautauqua County, N. Y. A plant has been erected and shipments are expected to begin in 1919. The Pennsylvania deposit is at Harmonsburg, Crawford County, and has been in operation three years. The West Virginia plant has been in operation two years and is at Charles Town, Jefferson County. No sales were reported in 1918 from the deposits near San Jose, Santa Clara County, and Lemon Cove, Tulare County, Calif. In Arkansas the material reported is chalk and the deposit is at White Cliff, Little River County.

Marine marl, derived from fragments of the shells of marine animals, was produced in 1918 at five deposits in the Coastal Plain region of North Carolina and South Carolina. The output amounted to 40,873 short tons, valued at $112,209, or $2.75 a ton, compared with 25,986 tons, valued at $53,148, or $2.05 a ton, in 1917, an increase of 14,887 tons (57 per cent) in quantity and $59,061 (111 per cent) in value. These deposits are near Charleston, S. C., and near Newbern, Craven County, and Polloksville, Jones County, N. C.

DEALERS.

Lime sold to dealers in 1918 constituted only 3.5 per cent of the total sold and showed a decrease of 43 per cent in comparison with the sales to dealers in 1917. This large decrease was probably due to the same causes as the decrease in 1917—much better knowledge of the ultimate uses of the lime and a larger percentage of the quantity going directly to the consumer.

OTHER USES.

Under "other uses" is included lime for at least 30 different purposes that can not properly be classified with the principal uses already named. The total lime sold for "other uses" in 1918 amounted to 499,063 tons in quantity and $5,476,895 in value—an increase compared with 1917 of 80 per cent in quantity and 108 per cent in value. In 1917 lime for "other uses" made up only 7.3 per cent of the total quantity, but in 1918 it made up about 15.6 per cent.

The quantity of lime sold for "other uses" increased steadily from 1908 to 1916 (fig. 94). In 1916 lime for metallurgy was made a separate item. This caused a marked decrease in the quantity of lime still recorded under "other uses" (fig. 95). In 1917 lime for glass works was made a separate item, and this caused another decrease. Notwithstanding the fact that two important items were taken out and put into separate classes, the quantity of lime for "other uses" in 1918 was by far the largest yet recorded. The average price advanced from $9.52 in 1917 to $10.97 in 1918.

Lime for refractories, almost all of which was dead-burned dolomite, made up about 64 per cent of all the lime sold for "other uses." Four States (Pennsylvania, Ohio, New York, and Indiana) produced all the dead-burned dolomite in 1918. Pennsylvania and Ohio together produced 295,737 tons. Part of the dead-burned dolomite credited to Ohio was quarried in Ohio, but burned in West Virginia. Besides the quantity here recorded, which was burned by the producers, 490,863 short tons of raw dolomite, valued at $560,209,

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was sold for this purpose by producers of stone. Dead-burned dolomite has been extensively used to replace Austrian magnesite for maintaining the bottoms and lining the walls of open-hearth and electric furnaces. Its future depends largely on the extent to which it can compete with domestic and foreign magnesite when normal conditions are again restored. The total quantity sold in 1917, including the dead-burned equivalent of the raw dolomite just mentioned, exceeded the combined quantity of domestic and imported magnesite (figured as the calcined product) sold in that year. The total quantity sold in 1918 showed a substantial increase over that in 1917, although several other refractories and metallurgical products decreased. These facts indicate a wider use than was formerly supplied by magnesite, and imply that although it owes its prominence to war conditions it is likely to retain its importance.

About 15 per cent of lime for "other uses" was used for water purification and softening. The remaining 21 per cent is itemized in the following table:

Lime sold for "other uses" in 1918.

Use.	Quantity (short tons).	Value.
Refractories	318,896	$4,097,819
Silica brick	26,517	182,659
Sand-lime brick	7,417	59,357
Soap	29,599	202,028
Lubricating grease, renovating of butter, etc	3,395	28,410
Kalsomine	999	9,076
Water purification and softening	75,448	596,667
Sewage purification and neutralization of acid water	9,514	68,668
Disinfectants	6,059	51,438
Glue manufacture	8,822	78,599
Pottery and porcelain manufacture	129	1,213
Polishing and buffing compounds	384	4,424
Cotton, thread and woolen mills	2,117	21,425
Flour mills	164	1,785
Spraying	1,813	16,706
Undistributed[a]	7,790	56,621
	499,063	5,476,895

[a] Includes small quantities of lime reported as sold for manufacture of candles, corn products, dyes, rubber, proprietary medicines, varnish, graphite, for refining gold and platinum, for use in slag cement, in print works, tobacco factories, copper and file works, for sheep dip, and other uses not specified.

During 1918 the Lime Association, through its chemical bureau, began a systematic study of the many chemical uses of lime. The work has thus far disclosed a surprising lack of regard on the part of chemists in manufacturing plants for the properties and purity of lime. It is expected that more care, in at least some of the uses of lime listed above and on page 835, will lead to an increased appreciation of lime as a chemical reagent and to a consequent increased demand for it. This first appearance of these tables is therefore timely and will also serve as a guide to manufacturers in efforts to increase their range of markets.

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HYDRATED LIME.

The production of hydrated lime, like that of quicklime, was considerably reduced in 1918, but the decrease in quicklime amounted to 16 per cent, whereas the decrease in hydrated lime amounted to only 12.5 per cent. This decrease followed a slight decrease in 1917, which was the first since the slight decrease in 1911. The greatest production of hydrated lime was recorded in 1916 and amounted to 717,382 tons. In value the hydrated lime production of 1918 was an increase of $699,109, or 15 per cent, compared with that of 1917, and was by far the largest ever recorded. The value of hydrated lime has increased continuously and rapidly ever since 1908 (Pl. VII). The average price per ton increased from $6.55 in 1917 to $8.61 in 1918. From 1906 up to and including 1915 the price has fluctuated between $4 and $4.50, but since 1915 there has been a steady increase. The price in 1918 was an increase of 104 per cent over the price of 1915. The production of hydrated lime made up 19 per cent of the total quantity of lime produced in the United States in 1918.

Hydrated lime manufactured and sold in the United States, 1906–1918.

Year.	Quantity (short tons).	Value.	Average price per ton.	Number of plants reporting operations.
1906	120,357	$479,079	$3.98	30
1907	140,135	657,636	4.69	33
1908	136,411	548,262	4.02	46
1909	204,611	904,900	4.43	50
1910	320,819	1,288,789	4.02	51
1911	304,593	1,372,057	4.50	60
1912	416,890	1,829,064	4.39	64
1913	493,269	2,205,657	4.47	80
1914	515,121	2,239,916	4.35	82
1915	581,114	2,457,602	4.23	84
1916	717,382	3,626,998	5.06	89
1917	709,157	4,643,004	6.55	90
1918	620,216	5,342,113	8.61	90

Ninety hydrated-lime plants were in operation in this country in 1918, the same number as in 1917. These plants were distributed in 25 States. Hawaii was added to the list of hydrated-lime producers in 1918. A decrease in the number of plants operating was noted in California, Illinois, Maryland, New York, Virginia, Washington, and West Virginia, each of which lost one plant. On the other hand, Massachusetts increased its number of plants from 1 to 3, Pennsylvania from 13 to 16, and Wisconsin from 2 to 3.

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Lime-hydrating plants in operation in 1909–1918.

State or Territory.	1909	1910	1911	1912	1913	1914	1915	1916	1917	1918
Alabama	3	2	2	2	2	3	3	3	3	3
Arizona	1	1	1	.....	.....	.....	.....	1	1	1
California	2	2	3	3	4	2	2	1	3	2
Colorado	1	1	.....	.....	.....	.....	.....	.....	.....	.....
Connecticut	1	.....	.....	1	.....	1	1	1	1	1
Florida	.....	1	.....	.....	1	.....	1	1	1	1
Georgia	.....	.....	1	1	1	.....	.....	.....	.....	.....
Hawaii	.....	1	.....	.....	.....	.....	1	.....	.....	1
Idaho	1	1	1	1	.....	.....	1	.....	1	1
Illinois	2	2	1	1	1	1	1	2	3	2
Indiana	2	2	2	2	2	3	3	3	3	3
Iowa	1	.....	.....	.....	1	1	.....	1	.....	.....
Kansas	1	.....	.....	.....	.....	.....	.....	.....	.....	.....
Kentucky	.....	.....	.....	.....	1	1	.....	.....	.....	.....
Maine	1	1	1	1	1	1	1	1	1	1
Maryland	1	3	3	3	4	6	5	7	7	6
Massachusetts	.....	1	2	.....	1	1	1	1	1	3
Michigan	1	2	3	1	3	2	3	2	2	2
Missouri	3	3	3	4	4	6	5	6	7	7
New Jersey	1	.....	2	1	1	1	1	1	.....	.....
New York	3	.....	2	3	4	4	6	9	4	3
North Carolina	.....	.....	1	.....	.....	.....	.....	.....	.....	.....
Ohio	8	11	15	17	19	20	21	20	20	20
Pennsylvania	9	8	8	15	15	14	11	11	13	16
Rhode Island	.....	.....	.....	.....	.....	1	1	1	.....	.....
South Dakota	.....	1	1	.....	1	1	1	1	1	1
Tennessee	1	1	1	1	2	2	2	3	3	3
Texas	3	3	3	3	3	3	3	3	3	3
Vermont	.....	.....	.....	.....	.....	.....	.....	1	1	1
Virginia	2	.....	1	.....	2	1	2	2	3	2
Washington	.....	.....	1	1	2	2	2	2	2	1
West Virginia	.....	2	1	2	3	3	4	3	4	3
Wisconsin	2	2	1	1	2	2	2	2	2	3
	50	51	60	64	80	82	84	89	90	90

As only 11 States had three or more companies operating hydrating plants in 1918, the totals of the other States could not be published without revealing individual figures. The following table is therefore very incomplete:

Hydrated lime sold in the United States in 1917 and 1918.

State.	1917		1918	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Alabama	6,541	$48,089	6,327	$61,271
Arizona	(a)	(a)	(a)	(a)
California	3,512	31,529	(a)	(a)
Connecticut	(a)	(a)	(a)	(a)
Florida	(a)	(a)	(a)	(a)
Hawaii	(a)	(a)	(a)	(a)
Idaho	(a)	(a)	(a)	(a)
Illinois	(a)	(a)	(a)	(a)
Indiana	21,867	134,835	24,574	191,631
Maine	(a)	(a)	(a)	(a)
Maryland	20,580	143,133	25,218	232,629
Massachusetts	(a)	(a)	8,803	82,699
Michigan	(a)	(a)	(a)	(a)
Missouri	32,120	219,600	34,942	345,754
New York	8,562	58,852	(a)	(a)
Ohio	316,252	2,038,944	234,902	2,060,369
Pennsylvania	142,254	974,936	133,583	1,126,957
South Dakota	(a)	(a)	(a)	(a)
Tennessee	18,594	126,455	19,268	135,612
Texas	13,999	93,861	15,594	129,044
Vermont	(a)	(a)	(a)	(a)
Virginia	7,393	46,864	(a)	(a)
Washington	(a)	(a)	(a)	(a)
West Virginia	51,545	274,718	46,485	345,123
Wisconsin	(a)	(a)	16,883	117,754
Undistributed	65,938	451,188	53,637	513,270
	709,157	4,643,004	620,216	5,342,113

a Included in "Undistributed."

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Ohio was again the leading producer of hydrated lime, and Pennsylvania was second. Both of these States showed decreases in quantity but increases in value. In Ohio the quantity decreased 26 per cent and in Pennsylvania 6 per cent. In Indiana, Maryland, Missouri, Tennessee, and Texas, however, there was an increase in the quantity as well as the value of hydrated lime produced.

Hydrated lime for building constituted 50 per cent of the total hydrated lime. There was a decrease of 89,624 tons, or 22 per cent, compared with the hydrated lime consumed for building in 1917. The value, however, increased 4 per cent.

A large quantity of hydrated lime (29 per cent of the total) was also used for agricultural purposes. This class of lime increased slightly in quantity. The increase in value amounted to 30 per cent.

The decrease in the use of hydrated lime for chemical purposes was very marked, even the value in this case being lower for 1918 than for 1917. There was a marked increase, however, in hydrated lime for "other uses," even more than for quicklime for that purpose. This increase was undoubtedly due to the same cause as the increase in quantity of quicklime for this purpose—the more detailed classification under "other uses" and the inclusion under that head of lime which in 1917 would have been included under chemical lime. The hydrated lime sold to glassworks dropped from 2,827 tons in 1917 to to 922 tons in 1918.

Although quicklime sold to dealers showed a very marked decrease, hydrated lime showed an increase of 1,925 tons, or 6 per cent, in quantity and an increase of 46 per cent in value.

Hydrated lime sold in the United States in 1917 and 1918, by uses.

Use.	1917		1918	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Building	402,223	$2,694,143	312,599	$2,800,077
Chemical	52,255	354,177	31,107	282,501
Paper mills	6,728	43,513	10,756	101,523
Sugar factories	5,227	38,298	7,471	61,807
Tanneries	13,979	91,554	13,557	122,317
Glass factories	2,827	19,358	922	8,509
Agriculture	177,815	1,114,359	181,890	1,452,436
Dealers	30,630	170,732	32,555	249,590
Other	17,473	116,870	29,359	263,353
	709,157	4,643,004	620,216	5,342,113

CONSUMPTION.

In considering any table giving figures on consumption of lime by States it must be remembered that the relation of production to consumption is governed by many factors—the presence of large workable deposits of limestone within a State and the distance of that State from States without such deposits; the availability of transportation lines from the State; the presence of large centers of population in a State and their proximity to limestone deposits in the same State or in other States. Small quantities of lime, of an exceptional grade, may be shipped long distances for special purposes.

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Lime consumed in the United States in 1918, in short tons.

State.	Production.	Shipments from State.	Shipments into State.	Consumption.					Population in 1918 (estimated).
				Quicklime.	Hydrated lime.	Total lime.	Per capita (estimated).		
							1917	1918	
Alabama	49,209	31,443	3,684	18,819	2,631	21,450	0.01	0.01	2,395,270
Alaska			27	27		27		.0004	64,900
Arizona	11,212	7,306	3,855	7,613	148	7,761	.02	.03	272,034
Arkansas	8,320	3,803	3,179	6,115	1,581	7,696	.006	.004	1,792,965
California	55,588	1,297	8,804	58,439	4,656	63,095	.03	.02	3,119,412
Colorado	6,077		6,584	11,631	1,030	12,661	.016	.01	1,014,581
Connecticut	(a)	(a)	18,905	28,195	3,503	31,698	.03	.02	1,286,268
Delaware			53,164	37,925	15,239	53,164	.19	.245	216,941
District of Columbia			10,942	4,125	6,817	10,942	.03	.03	374,584
Florida	(a)	(a)	5,107	3,939	5,111	9,050		.010	938,877
Georgia			24,477	15,815	8,661	24,477	.01	.01	2,935,617
Hawaii	(a)		(a)	2,683	146	2,829	.015	.01	223,419
Idaho	(a)	(a)	4,098	2,280	2,267	4,547	.01	.01	461,766
Illinois	64,672	26,336	143,531	155,812	26,055	181,867	.04	.03	6,317,734
Indiana	116,321	72,033	51,357	65,878	29,767	95,645	.03	.03	2,854,167
Iowa	(a)	(a)	19,669	18,056	8,646	26,702	.01	.01	2,224,771
Kansas	(a)	(a)	20,640	16,717	4,023	20,740	.01	.01	1,874,195
Kentucky	1,884		18,621	17,759	2,746	20,505	.008	.008	2,408,547
Louisiana			27,340	19,168	8,172	27,340	.015	.01	1,884,778
Maine	83,034	37,900	47,720	91,119	1,735	92,854	.13	.12	782,191
Maryland	106,737	53,595	91,782	105,307	39,617	144,924	.12	.10	1,384,539
Massachusetts	123,697	100,130	57,897	73,749	7,715	81,464	.03	.02	3,832,790
Michigan	134,813	9,241	67,083	163,729	28,926	192,655	.07	.02	3,133,678
Minnesota	10,792	5,324	13,562	12,788	6,242	19,030	.01	.01	2,345,287
Mississippi			7,648	7,204	444	7,648	.006	.004	2,001,466
Missouri	201,737	154,451	15,315	54,516	8,085	62,601	.02	.02	3,448,498
Montana	(a)	(a)	2,680	5,739	2,105	7,844	.015	.016	486,376
Nebraska			12,338	10,198	2,140	12,338	.01	.01	1,296,877
Nevada	(a)	(a)	1,197	5,444		5,444	.07	.05	114,742
New Hampshire			34,111	34,051	60	34,111	.068	.076	446,352
New Jersey	2,208	50	108,292	74,353	36,097	110,450	.04	.03	3,080,371
New Mexico	(a)	(a)	1,729	3,005	121	3,126	.007	.007	437,015
New York	87,127	48,999	177,730	169,081	46,777	215,858	.028	.02	10,646,989
North Carolina	(a)	(a)	38,148	35,265	6,278	41,543	.02	.02	2,466,025
North Dakota			1,845	610	1,235	1,845	.003	.002	791,437
Ohio	489,893	292,982	76,701	182,701	90,911	273,612	.055	.052	5,273,814
Oklahoma	(a)	(a)	16,439	13,946	5,220	19,166	.01	.01	2,377,629
Oregon	2,257	1,523	4,961	4,904	791	5,695	.015	.006	888,243
Pennsylvania	801,834	239,832	209,845	633,124	138,723	771,847	.10	.085	8,798,067
Porto Rico	3,973			3,973		3,973	.003	.003	1,247,677
Rhode Island	(a)	(a)	6,636	5,906	825	6,731	.016	.015	637,415
South Carolina			11,886	9,506	2,380	11,886	.01	.007	1,660,934
South Dakota	4,772		3,705	6,299	2,178	8,477	.01	.01	735,434
Tennessee	106,527	73,025	2,515	33,171	2,846	36,017	.01	.015	2,321,253
Texas	45,206	16,858	653	17,644	11,357	29,001	.01	.006	4,601,279
Utah	7,844	21	163	7,823	163	7,986	.025	.017	453,648
Vermont	35,728	32,929	537	2,805	531	3,336	.025	.01	366,192
Virginia	249,990	83,149	29,378	179,648	16,571	196,219	.10	.09	2,234,030
Washington	22,118	8,257	1,276	12,475	2,662	15,137	.01	.009	1,660,578
West Virginia	167,901	159,658	22,935	19,606	11,572	31,178	.025	.02	1,439,165
Wisconsin	109,303	55,276	61,174	102,942	12,259	115,201	.055	.045	2,553,983
Wyoming	(a)		(a)	1,244	722	1,966	.01	.01	190,380
Undistributed	95,242	51,198	2,094						
	3,206,016	b1,566,616	1,553,959	2,574,872	618,487	3,193,359	.037	.030	106,795,270

a Included in "Undistributed."
b Includes 516 tons shipped to Mexico, 33 tons shipped to South America, and 12,108 tons shipped to Canada.

Production exceeded consumption in 15 States. Of these States Indiana, Massachusetts, Missouri, Ohio, Pennsylvania, Tennessee, Virginia, and West Virginia were large producers. Some States produce large quantities of lime for which there is little demand within the State and ship this lime to neighboring States. Such a State is Alabama, which ships most of its lime to Georgia, Mississippi, Louisiana, and South Carolina.

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In three of the New England States—Vermont, Massachusetts, and Connecticut—production exceeded consumption. A great part of the product from these States was shipped to other New England States and to New York. Small quantities went to Pennsylvania, Ohio, and Canada. New Hampshire produced no lime, but consumed about 34,000 tons. Shipments into New England States came principally from other New England States and from New York with smaller quantities from Pennsylvania, Ohio, Maryland, and Missouri.

New York consumed more than twice as much as it produced. It made shipments of small quantities to 18 States and Canada, but it received large quantities from Ohio, Pennsylvania, Massachusetts, Maine, and West Virginia, and small lots from Southern and Central States. Pennsylvania, although the largest producer, consumed almost as much as it produced. This State shipped to 23 other States and to Canada, the largest quantities going to New Jersey, New York, Maryland, Delaware, and Ohio. Shipments into Pennsylvania came from Maryland, Ohio, New York, Virginia, and West Virginia. Pennsylvania consumed more than three times as much as any other State except Ohio.

All of New Jersey's production was used for home consumption. In addition, this State received lime from nine States, including Pennsylvania, Ohio, Maryland, Massachusetts, and New York.

Delaware produced no lime, but consumed about 53,000 tons, and, as usual, led all States in consumption of lime per capita.

Among the Southern States there were four in which production was far greater than consumption—Virginia, West Virginia, Tennessee, and Alabama—and five in which consumption greatly exceeded production—Kentucky, North Carolina, South Carolina, Georgia, and Florida. Although Virginia was the greatest consumer among the Southern States, its production exceeded its consumption, and it made large shipments to Maryland, North Carolina, Pennsylvania, New Jersey, and New York. The States in this section that consumed large quantities obtained their lime from the other Southern States and from Ohio and Maryland, while the large producers in the South supplied the other Southern States and also Pennsylvania, Ohio, and Maryland.

The section which includes Ohio, Indiana, Illinois, Michigan, and Wisconsin produced 29 per cent of the total quantity of lime produced in the United States. In these States there are a great many workable limestone deposits, but there are also many large industrial centers, and therefore this section consumes almost as much as it produces. Ohio produced in 1918 much more than it consumed and shipped to 32 States and to Canada. Illinois, on the other hand, consumed twice as much as it produced, and received lime in large quantities from Missouri, Wisconsin, Ohio, and Indiana. Indiana produced slightly more than it consumed. Its principal shipments were made to Illinois, Kentucky, Ohio, Michigan, and Wisconsin. A small quantity was shipped to Canada. Michigan consumed more than it produced. It shipped lime to only three States—Indiana, Minnesota, and Wisconsin—but it received large quantities from Ohio, West Virginia, Indiana, and other States. Wisconsin also consumed slightly more than it produced.

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Missouri supplied a large quantity of the lime for other States, for while its production was 201,737 tons, its consumption was only 62,601 tons, less than one-third of the production. It made shipments to 29 States, Canada, and Mexico, the largest quantities going to Illinois, Wisconsin, Kansas, Oklahoma, and Iowa.

Iowa, Kansas, Minnesota, North Dakota, South Dakota, and Nebraska all consumed more than they produced. North Dakota and Nebraska had no production. A great part of the lime shipped into the States of this section came from Missouri, although Wisconsin, Ohio, and Illinois also supplied considerable quantities.

Although Louisiana had no production, it consumed 27,340 tons, this quantity coming principally from Alabama, Tennessee, Texas, and Missouri.

Both production and consumption amounted to very little in Arkansas and New Mexico. In Oklahoma consumption greatly exceeded production. Oklahoma shipped lime outside the State to Texas only, but it received shipments from Texas, Missouri, and Arkansas, and a small quantity from Ohio.

Production exceeded consumption in Texas by 16,205 tons. This surplus was shipped in great part to other Southwestern States.

Production in the Rocky Mountain States—Montana, Wyoming, Colorado, and Utah—amounted to 19,156 tons, but consumption in these States exceeded this quantity by 11,301 tons. This excess consumed came principally from Missouri and Washington, with small quantities from several other Western States, as well as from Illinois and Pennsylvania.

Arizona produced 11,212 tons, of which more than half was shipped out of the State, practically all to California. A few thousand tons were received from Texas and a very small quantity from California.

Both consumption and production were small in Idaho, Nevada, and Oregon, but consumption exceeded production. Lime was received in these States from California, Washington, and Alabama. The whole quantity received from Alabama was hydrated lime. Small shipments were received from other Western States.

California consumed a little more lime than it produced. It made small shipments to Arizona, Nevada, and Oregon and received fairly large quantities from Arizona and Nevada and small quantities from Washington and Ohio, besides imports from British Columbia.

Washington produced 6,981 tons more than it consumed. Lime shipped out of the State amounted to 8,257 tons. Oregon received a large part of these shipments, and other Pacific Coast and Rocky Mountain States and Canada received smaller portions. A small shipment was made to Hawaii.

Canada received 12,108 tons of lime from the United States, more than half of this coming from New York State. Eight other States —Indiana, Michigan, Missouri, Ohio, Pennsylvania, Vermont, Washington, and West Virginia—supplied smaller quantities.

Only 516 tons was shipped to Mexico, all of it furnished by Arizona, Missouri, and Ohio.

A comparison of the rank of States by production and by consumption shows some interesting facts, although it must be borne in mind that because a State has a higher rank in production than it has in consumption it does not necessarily mean that the State's actual

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production exceeded its actual consumption; sometimes the reverse is true.

Pennsylvania and Ohio were first and second, respectively, in both consumption and production, but New York, which was third in consumption, was twelfth in production. In spite of New York's rather abundant deposits of limestone, its principal centers of consumption are most readily supplied from adjacent States. Illinois was sixth in consumption but fourteenth in production, its principal consuming district, Chicago, being readily supplied from plants on the Great Lakes, and its southern part being most readily supplied from Missouri. New Jersey, which consumed all the lime produced in the State and imported large quantities from conveniently situated districts and districts producing certain grades of lime, was ninth in consumption and thirty-seventh in production. Delaware, which contains no deposits of limestone, received such large quantities of lime from other States that it took fifteenth place in consumption. North Carolina was sixteenth in consumption, but twenty-seventh in production, as its active kilns are situated in its western part more convenient to cities in South Carolina than to several of its own important cities, and as its demands are largely for higher calcium lime than it has heretofore produced. Kansas for the same general reasons was twenty-sixth in consumption but fortieth in production.

On the other hand, Missouri was fourth in production but sold so much of its lime outside the State that it was only fourteenth in consumption. The conditions were about the same in West Virginia, for it was fifth in production but twentieth in consumption.

CONSUMPTION PER CAPITA.

In 1918 the average consumption of lime per capita decreased to 0.030 short ton, compared with 0.037 short ton in 1917 and 0.040 short ton in 1916. Delaware again had the highest per capita consumption, which increased from 0.19 to 0.245 ton. The district surrounding Delaware, including Maryland, Virginia, and Pennsylvania, also showed a very high per capita consumption, though less than in 1917, because of the marked decrease for building, agricultural, and certain chemical uses. New Jersey and the District of Columbia continued to maintain about the average rate of the country, but Massachusetts and Connecticut declined somewhat further below the average than they did in 1917. Similar relative declines, as was to be expected, characterized all sections of the country. The only State besides Delaware with relatively high per capita consumption to show increase was New Hampshire. Tennessee, Montana, and Arizona increased their small rates. Porto Rico, North Dakota, and Alaska had the lowest per capita consumption.

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IMPORTS.

Imports have varied considerably in the last few years, although neither the quantity nor the value have reached the figures for 1909. The imports for 1918 decreased 9.6 per cent in quantity but increased 4 per cent in value as compared with 1917.

Lime imported and entered for consumption in the United States, 1909–1918.[a]

Year.	Quantity (short tons).	Value.	Year.	Quantity (short tons).	Value.
1909	8,687	$75,556	1914	3,455	$33,670
1910	6,498	63,791	1915	1,956	22,489
1911	5,232	55,255	1916	7,959	71,663
1912	4,268	48,153	1917	7,353	70,505
1913	4,139	48,538	1918	6,650	73,458

[a] Most of the lime imported into the United States comes from Canada.

EXPORTS.

Exports of lime, as shown in the following table, decreased in quantity as well as in value in 1918. They represent 0.2 per cent of the quantity marketed, compared with 0.5 per cent in 1917.

Lime exported from the United States, 1913–1918.

Year.	Quantity (short tons).	Value.	Average price per ton.	Year.	Quantity (short tons).	Value.	Average price per ton.
1913	29,475	$212,345	$7.20	1916	23,973	$132,769	$5.54
1914	24,141	170,744	7.07	1917	18,794	168,671	8.97
1915	16,223	106,312	6.55	1918	7,191	105,803	14.71

The statistics in the following table were compiled from records of the Bureau of Foreign and Domestic Commerce, United States Department of Commerce:

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Lime exported from the United States, 1917–1918.

Country.	1917		1918	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Canada	16,087	$122,635	5,337	$59,186
Newfoundland and Labrador			8	116
Mexico	773	11,450	520	9,702
Central America:				
British Honduras	6	79	3	55
Guatemala	2	17	(a)	5
Honduras	313	3,554	319	6,113
Nicaragua	122	2,223	145	3,887
Panama	169	3,620	161	5,430
Salvador	6	93		
West Indies:				
Cuba	190	2,429	31	549
Dominican Republic	388	9,602	303	10,210
Virgin Islands of the United States	82	1,407	30	603
French West Indies	15	406		
Barbados	90	2,114		
Bermuda	(a)	12		
Trinidad and Tobago	5	104		
Other British West Indies	(a)	16	8	225
South America:				
Argentina	7	239		
Bolivia	(a)	10		
Brazil	2	45	132	5,051
Chile	192	3,246		
British Guiana	4	64		
Dutch Guiana	3	49		
Peru	113	1,773	171	3,941
Venezuela	5	160		
England	215	3,211		
Straits Settlements	(a)	18	2	185
British Oceania	2	56	(a)	8
French Oceania	3	37	4	78
German Oceania	(a)	2		
Philippine Islands			2	61
Dutch East Indies			6	156
British West Africa			9	242
	18,794	168,671	7,191	105,808

a Less than 1 ton.

A discrepancy will be noted between the figures for consumption, in which shipments to Canada amount to 12,108 tons, and the figures for export, in which shipments to Canada amount to only 5,337 tons. The consumption figures are gathered from shipment statements of manufacturers and the export figures are collected by United States agents at the ports. Part of the discrepancy is no doubt due to the fact that shipments of lime to foreign countries are often consigned at the plant before the end of the year, but do not leave the port for foreign shores until after the beginning of the following year. It often happens, too, that shipments of lime designated for foreign countries at the plant are diverted by agents to destinations within the United States before they reach the ports.

FUELS.

The following table shows the distribution by States of kilns using various kinds of fuels. The total number of kilns decreased about 20 per cent in 1918, as compared with 1917. The kilns using coal decreased 22 per cent, from 1,138 in 1917 to 885 in 1918. The number of kilns using coal increased from 31 to 34 in Indiana, from 26 to 36 in Maryland, from 24 to 29 in Missouri, and from 14 to 17 in

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Texas, but the number decreased from 280 to 174 in Ohio, from 502 to 400 in Pennsylvania, and from 42 to 27 in Tennessee. Less marked variations occurred in other States. The decrease in the number of kilns using wood in 1918 amounted to 28 per cent. The greatest decreases occurred in States where wood was largely used—Florida, Maine, Missouri, New York, and Wisconsin. The number of wood-burning kilns in Wisconsin decreased from 72 to 34. The number of wood-burning kilns increased in Porto Rico from 16 to 25, in Pennsylvania from none to 7, and in Tennessee from 1 to 9.

The number of kilns burning oil decreased from 27 in 1917 to 24 in 1918. Only three States used oil-burning kilns—California, Hawaii, and Nevada. Kilns using natural gas were reported only from Ohio and Pennsylvania in 1918 and showed a decrease from 25 in 1917 to 21 in 1918. Producer gas was used in kilns in 12 States, the largest number being found in Ohio, Michigan, and Pennsylvania. The number of kilns using this fuel decreased 12 per cent in 1918. The greatest number of coke-fired kilns are found in Pennsylvania, Maryland, West Virginia, and Virginia. These decreased about 20 per cent in 1918. Kilns burning a mixture of coal and wood were used in 17 States, particularly Missouri, Alabama, Pennsylvania, Connecticut, and Massachusetts, and the number in use in 1918 remained the same as for 1917. Kilns burning mixed coal and coke were used in only three States in 1918—Maryland, Pennsylvania, and Virginia, and this number decreased from 51 in 1917 to 37 in 1918.

At least five companies used lignite as fuel in 1918. This has been included under coal in the table showing the various kinds of fuel used.

One producer reports that lignite compares favorably with other fuels, both in cost and the quality of lime produced. A lignite containing a large percentage of moisture produces a soft-burned lime similar to lime burned with wood. It usually requires about half a ton of lignite to burn a ton of lime. If lignite is to be used efficiently, it should be burned in a kiln having a fire box with large grate area and a high arch or combustion chamber. The kiln should also have a taller shaft than usual since the gases in lignite distill off very rapidly. Unless a high arch in combustion chamber and a tall shaft for the kiln are used the gases will burn on top of the kiln. Lignite can not be stored but must be used fresh. After storing lignite a week or two it will produce only about half the quantity of lime it does when used fresh.[1]

[1] Remarks on lignite from personal communication of H. Dittlinger to G. F. Loughlin.

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Number of limekilns using various kinds of fuel in 1917 and 1918.

1917.

State.	Coal.	Wood.	Oil.	Natural gas.	Producer gas.	Coke.	Coal and wood.	Coal and coke.	Total.
Alabama	4	1					12		17
Arizona		5							5
Arkansas		7							7
California		6	23			5			34
Colorado	8								8
Connecticut	4	2			2		18		26
Florida		11							11
Hawaii			1						1
Idaho	1	6							7
Illinois	4	4		7			[a] 27		42
Indiana	31				2				33
Iowa		4							4
Kentucky	1	3							4
Maine	40	18							58
Maryland	26	4				50	3	[a] 28	111
Massachusetts	17	5			9		11		42
Michigan	2	17			16				35
Minnesota	8	4							12
Missouri	24	10			3		44		81
Montana	1	6							7
Nevada			3						3
New Jersey	6								6
New Mexico	3								3
New York	27	16			2				45
North Carolina							5		5
Ohio	280	6		[a] 16	31				333
Oklahoma		2							2
Oregon		3					3		6
Pennsylvania	502				10	65	23	20	620
Porto Rico	1	16							17
Rhode Island		1							1
South Dakota	2	3							5
Tennessee	42	1			1		8		52
Texas	14			2		2			18
Utah	5	3				6			14
Vermont		6			4		7		17
Virginia	52	13			3	22	12	3	105
Washington		12					1		13
West Virginia	33	1			3	39	7		83
Wisconsin		72							72
Wyoming							1		1
	1,138	268	27	25	86	189	182	51	1,966

[a] Includes in Illinois 13 kilns using shavings; in Maryland, 20 kilns using coal, wood, and coke: in Ohio, 2 kilns using coal, wood, and natural gas.

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Number of limekilns using various kinds of fuel in 1917 and 1918—Continued.

1918.

State.	Coal.	Wood.	Oil.	Natural gas.	Producer gas.	Coke.	Coal and wood.	Coal and coke.	Total.
Alabama	4	2					23		29
Arizona		4							4
Arkansas		5							5
California		3	21			2			26
Colorado	7								7
Connecticut	4	2			2		18		26
Florida		4							4
Hawaii			1						1
Idaho	2					1			3
Illinois	5	3			4		12		24
Indiana	34	1			2				37
Iowa	1	3							4
Kansas	1								1
Kentucky		3							3
Maine	13	14							27
Maryland	36	2				32	3	17	90
Massachusetts	12				7		17		36
Michigan	3	14			14				31
Minnesota	5	4							9
Missouri	29	6			6		36		77
Montana		4					2		6
Nevada			2						2
New Jersey		6							6
New Mexico	2								2
New York	26	7			3		1		37
North Carolina							4		4
Ohio	174	2		20	21				217
Oklahoma		1					1		2
Oregon	3						2		5
Pennsylvania	400	7		1	8	68	23	17	524
Porto Rico		25							25
Rhode Island		1							1
South Dakota		2					1		3
Tennessee	27	9					12		48
Texas	17	1				2			20
Utah	7	1				6			14
Vermont		1			3		9		13
Virginia	48	8			3	18	13	3	93
Washington		15							15
West Virginia	24				3	22	5		54
Wisconsin		34							34
Wyoming	1								1
	885	194	24	21	76	151	182	37	1,570

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Percentage of total number of kilns using various kinds of fuels, 1908–1918.

Year.	Coal.	Wood.	Oil.	Natural gas.	Producer gas.	Coke.	Shavings.	Coal and wood.	Coal and coke.
1908	57.0	27.0	1.1	1.6	.....	1.1	.....	[a] 11.4	0.8
1909	53.1	19.7	.5	.8	.....	1.5	.....	[a] 22.7	1.7
1910	54.0	22.3	.8	.8	1.1	1.9	.....	[a] 16.0	[a] 3.1
1911	57.0	18.0	2.3	1.5	3.2	3.2	1.2	[a] 12.0	1.6
1912	59.0	19.3	2.7	1.9	2.4	3.2	1.4	8.4	1.7
1913	57.1	19.7	2.3	1.3	3.3	5.2	.8	9.4	.9
1914	59.9	17.5	2.0	1.6	3.6	7.0	.8	6.5	1.1
1915	53.5	17.0	1.5	1.8	3.6	11.5	1.1	7.5	2.5
1916	53.6	18.2	1.7	1.5	3.8	9.6	.4	7.5	3.7
1917	57.9	13.6	1.4	1.3	4.4	9.5	.....	9.3	2.6
1918	56.4	12.4	1.5	1.3	4.8	9.6	.....	11.6	2.4

[a] Includes a small percentage of kilns burning unspecified mixtures of fuels.

KILNS.

The following definitions of the different types of limekilns are those suggested by W. E. Emley: [1]

A "field" kiln is distinguished from all other types by being intermittent in its operation. Firing is continued until the contents of the kiln are calcined, when the kiln is entirely emptied. Under some conditions it may be demolished and rebuilt after each burn. A "continuous" kiln is a kiln of any type other than a field kiln.

A "pot" kiln is a vertical shaft kiln which is continuous in its operation. Its peculiar characteristic is that the fuel and stone are charged into the kiln in alternate layers.

A "flame" kiln is a vertical shaft kiln which is continuous in its operation. Its name is derived from the fact that only the flame of the fuel and not the fuel itself comes into contact with the stone or lime. This type is sometimes known as a "patent" kiln, but the term "flame" is to be preferred as more significant.

The total number of kilns in use decreased about 20 per cent in 1918. All types of kilns showed a decrease with the exception of rotary kilns, which increased 42 per cent. In 1917 there were 19 rotary kilns in use; in 1918 there were 27. The fact that the number of rotary kilns increased despite the decrease in the total number of kilns in use would seem to indicate that the rotary kilns are beginning to be recognized as a very efficient type, not so much for their best economy as for their ability to burn smaller sizes of stone, which choke the draft in upright kilns, and to produce a good quality of lime, especially for hydrating plants.

As a part of the work of the Air Nitrates Corporation, financed by the Government, a lime plant was built at Muscle Shoals, Ala., in 1918, that was equipped with seven rotary kilns, each 8 by 125 feet.

[1] Lime: U. S. Geol. Survey Mineral Resources, 1917, pt. 2, p. 612, 1919.

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Capacity and kind of limekilns used in United States in 1917.

State.	Capacity (short tons per day).	Pot.	Flame.	Rotary.	Field and unspecified.	Total.
Alabama	317	9	14	.....	.....	23
Arizona	110	.....	10	.....	1	11
Arkansas	127	.....	12	.....	.....	12
California	494	11	17	6	2	36
Colorado	21	.....	.....	.....	8	8
Connecticut	300	.....	28	.....	.....	28
Florida	47	7	6	.....	4	17
Hawaii	25	.....	2	.....	.....	2
Idaho	42	2	5	.....	1	8
Illinois	426	15	28	.....	1	44
Indiana	486	.....	42	.....	1	43
Iowa	66	.....	6	.....	.....	6
Kentucky	13	1	.....	.....	3	4
Maine	458	.....	65	.....	.....	65
Maryland	605	88	10	.....	24	122
Massachusetts	439	7	35	2	10	54
Michigan	585	.....	38	1	.....	39
Minnesota	93	1	11	.....	1	13
Missouri	964	7	81	.....	3	91
Montana	74	4	4	.....	.....	8
Nevada	42	3	.....	.....	.....	3
New Jersey	25	8	.....	.....	4	12
New Mexico	12	2	1	.....	.....	3
New York	402	15	33	.....	9	57
North Carolina	20	.....	4	.....	1	5
Ohio	3,626	173	186	1	8	368
Oklahoma	22	1	1	.....	.....	2
Oregon	37	1	.....	.....	3	4
Pennsylvania	3,638	173	283	7	225	688
Porto Rico	.....	.....	.....	.....	23	23
Rhode Island	20	.....	3	.....	.....	3
South Dakota	9	1	2	.....	4	7
Tennessee	546	5	48	1	13	67
Texas	316	4	24	.....	2	30
Utah	96	3	9	.....	7	19
Vermont	243	4	15	1	5	25
Virginia	1,123	45	58	.....	24	127
Washington	216	5	20	.....	.....	25
West Virginia	1,095	43	27	.....	13	83
Wisconsin	1,437	11	96	.....	2	109
Wyoming	.....	.....	.....	.....	1	1
	18,617	649	1,224	19	403	2,295

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Capacity and kind of limekilns used in United States in 1918.

State.	Capacity (short tons per day).	Pot.	Flame.	Gas.	Rotary.	Field and unspecified.	Total number of kilns in State.	Total used 1918.
Alabama	361	2	23	.....	.....	1	29	32
Arizona	110	.....	3	.....	.....	1	4	10
Arkansas	127	1	4	.....	.....	.....	5	12
California	574	10	11	.....	5	.....	26	59
Colorado	37	.....	7	.....	.....	.....	7	9
Connecticut	260	.....	23	.....	.....	.....	26	32
Florida	56	.....	4	.....	.....	.....	4	15
Hawaii	24	.....	1	.....	.....	.....	1	2
Idaho	48	.....	3	.....	.....	.....	3	7
Illinois	413	2	15	4	.....	3	24	39
Indiana	615	1	34	2	.....	.....	37	57
Iowa	90	.....	4	.....	.....	.....	4	6
Kansas	10	.....	1	.....	.....	.....	1	6
Kentucky	22	.....	1	.....	.....	2	3	3
Maine	452	.....	27	.....	.....	.....	27	62
Maryland	1,066	76	12	.....	.....	2	90	116
Massachusetts	710	5	23	6	2	.....	36	51
Michigan	335	.....	16	14	1	.....	31	42
Minnesota	92	1	7	.....	.....	1	9	12
Missouri	1,025	2	68	6	.....	1	77	100
Montana	82	4	2	.....	.....	.....	6	8
Nevada	45	.....	2	.....	.....	.....	2	3
New Jersey	140	6	.....	.....	.....	.....	6	18
New Mexico	18	1	.....	.....	.....	1	2	5
New York	584	10	24	.....	3	.....	37	59
North Carolina	20	.....	4	.....	.....	.....	4	4
Ohio	4,222	42	166	.....	8	1	217	396
Oklahoma	22	2	.....	.....	.....	.....	2	2
Oregon	46	5	.....	.....	.....	.....	5	6
Pennsylvania	3,559	139	249	6	7	123	524	631
Porto Rico	.....	.....	.....	.....	.....	25	25	25
Rhode Island	20	.....	1	.....	.....	.....	1	3
South Dakota	29	2	1	.....	.....	.....	3	7
Tennessee	629	6	39	.....	.....	3	48	67
Texas	330	9	11	.....	.....	.....	20	30
Utah	59	10	.....	.....	.....	4	14	17
Vermont	308	4	5	2	1	1	13	26
Virginia	1,211	22	64	3	.....	4	93	113
Washington	241	4	11	.....	.....	.....	15	25
West Virginia	935	22	27	.....	.....	5	54	73
Wisconsin	1,164	6	27	.....	.....	1	34	93
Wyoming	5	1	.....	.....	.....	.....	1	1
	20,096	395	926	43	27	179	1,570	2,284

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CLAY-WORKING INDUSTRIES.[1]

By JEFFERSON MIDDLETON.

GENERAL CONDITIONS.

This report deals with the products of the clay-working industries as well as with clay mining, and the tables are made up to show the output in their first form of manufactured clay products as best expressing the production of clay.

The year 1918 was one of unusual conditions in the clay-working industries. The country was at war, and structural work, which normally consumes more than a third of the output of clay products, was restricted to the needs of the Government and essential war industries. Under these conditions all clay products except refractories and pottery (taken as a whole) decreased in value, compared with 1917.

The value of clay structural materials in 1918 was $66,209,300, a decrease of $19,450,587, or 23 per cent, compared with 1917. The clay products used chiefly in engineering works—vitrified paving brick or block, sewer pipe, and drain tile—were valued at $30,675,231 in 1918, a decrease of $8,304,703, or 21 per cent. The refractories—fire brick, including special shapes, and stove lining—were valued at $52,726,249, an increase of $9,130,985, or 21 per cent. No statistics are collected to show the quantity of stove lining marketed, but it seems quite probable that the increase in value in 1918 was caused by the increase in price rather than in output. Pottery products (valued at $65,222,951) also increased in value by $9,060,429, or 16 per cent. As the selling price of clay products per unit was much higher in 1918 than in 1917, the quantity of material, even where the value increased, was much less than in 1917. Notwithstanding the increase in value of refractories and pottery the net decrease in value of clay products in 1918 compared with 1917 was $10,628,122, or nearly 5 per cent. The total value of the clay products marketed in 1918 was $221,884,651.

The causes for these changes are not far to seek. In general the high cost and scarcity of materials, the uncertainty of labor, and unfavorable transportation conditions tended to curtail production. The decline in the demand for structural materials was felt early in the year on account of the decline in general building. Vitrified paving brick, sewer pipe, and drain tile, used principally in engineering works, should have apparently been in strong demand for roads and public utilities in Army camps and cantonments, but war conditions and Government restrictions caused the output to decrease.

[1] Tables of production were prepared by Miss Belle Worth Bagley and Miss Katrine W. Cottrell, and tables of imports and exports by J. A. Dorsey.

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The increase in refractories was due to the demand for them in the manufacture of iron and steel and allied industries. The large increase in the value of pottery was due to increased price rather than to increased output, though the potters were at times almost swamped with orders.

For some years silica fire brick were included with clay fire brick. Until 1916 their production and value were comparatively small and were not important factors in the total. Since 1915, however, the value of silica brick has increased so rapidly that it has been thought best to exclude silica brick from the table of clay products and to present the statistics concerning them in a separate statement.

The imports of clay products, 96 to 98 per cent of which have usually been pottery, showed in 1918 an increase of $41,627, or less than 1 per cent, compared with 1917. This increase was in pottery ($60,266), imports of brick and tile decreasing $18,639. Owing to the unusual demand at home, however, this slight increase had no apparent effect on the domestic production of pottery, the proportion of which to consumption was 93 per cent, the highest recorded.

The exportation of clay products, a comparatively unimportant but growing factor in the industries, showed another large increase in 1918 and reached the maximum value, $7,932,574, which was $979,311, or 14 per cent, greater than in 1917. Fire brick continues to be the principal clay product exported, its value in 1918 constituting 63 per cent of all exports. Canada is the best foreign market for clay products exported from the United States, 60 per cent of our exports going to that country in 1918.

In their statements to the Geological Survey the producers report quantities for common brick, face brick, vitrified brick or block, hollow building tile, and fire brick, but not for fancy brick or for enameled brick. The average price per thousand for these varieties increased as follows: Common brick from $8.17 to $10.90, vitrified brick or block from $15.09 to $17.74, and fire brick from $32.59 to $42.25. These advances seem no more than reasonable, except possibly in fire brick, compared with the increase in the cost of labor and materials. Only one variety of brick and tile, fire brick, reached its maximum value in 1918. No product reached its maximum output, so far as can be determined, as common brick, face brick, and vitrified brick or block each showed a large decrease in quantity.

The number of firms reporting sales continues to decrease, the number for 1918 being the smallest in the history of the industry and less than half of the maximum number reported for 1899. The decrease, which has been a steady one for many years, is caused principally by the elimination of the smaller plants, which is ascribed to the encroachment of cement or concrete and to the consolidation of plants for more efficient management. Undoubtedly, however, many plants were idle and made no sales of products in 1918—a condition which caused an additional decrease in the number reporting sales. The increase in the size of the operations is shown by the increase in the average value per active operator reporting, which increased from $13,760 in 1899 to $79,729 in 1918. The number of operators does not indicate the number of plants, as one operator may have more than one plant—in fact, some operators have a dozen or more. Clay products, except the highest grades, are made for local consumption, their low value preventing transportation for any considerable distances. Hence local conditions, including weather, seriously affect

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some branches of the clay-working industries. Imports consist chiefly of the highest grades of ware, principally pottery; and the European war, until this country entered it, had little direct effect on the brick and tile industries. Some of these wares, however, have been made from imported clays, especially from the high-grade English and German clays, and the decrease in the imports of the German clay has affected the manufacture of crucibles, lead pencils, and glasshouse pots, though domestic clays were being successfully used in 1918 in the manufacture of these wares to a greater extent than ever before.

The draft on labor for military purposes was not sufficient to cause any considerable introduction of female labor into the clay-working industries. Women were employed in the manufacturing phases of the industry at two brick and tile plants.[1] In the pottery industry little or no replacement of men by women took place, though had hostilities continued resort to such replacement on a large scale would have been necessary.

The immediate effect of the conditions prevailing in 1918 was of course the hampering of the industries. The ultimate effect, however, will be beneficial, as the necessity of economy in the production of wares was brought home to the operators as never before. The great impetus given to the development of improved kilns, designed to save time and fuel and labor, and the realization that machinery must play even a more important part in these industries in the future than in the past will be the principal benefits. The standardization both of refractory brick and of shapes inaugurated by Dr. Charles Catlett, of the War Industries Board, and the elimination of many patterns of pottery should also be beneficial.

FUEL RESTRICTIONS.

The clay-working industries were also subject to curtailment of fuel and to building and other restrictions imposed by the war boards with a view to making the country more efficient in the supreme business of the times, that of winning the war. The fuel curtailment order issued by the Fuel Administration to the clay-working industries under date of April 13, 1918, provided that the percentage of fuel allowed for these industries, as compared with that shown by the average consumption in 1915, 1916, and 1917, would be 50 per cent for common brick, paving brick, face brick, terra cotta, roofing tile, floor and wall tile, and sanitary ware; 75 per cent for hollow tile, sewer pipe, drain tile and flue lining; and 85 per cent for stoneware, except chemical stoneware.

By the courtesy of the Bureau of Statistics of the United States Fuel Administration the Geological Survey is enabled to publish the following table, which shows by States the quantity of coal consumed in the clay-working industries. These figures apparently do not include the pottery industry, except the manufacturers of stoneware and sanitary ware. The Fuel Administration had the following to say concerning the saving of coal by reason of its curtailment orders:[2]

Official reports from the clay-product industries, covering the first six months of 1918, showed a saving of 1,846,996 tons of coal resulting from the orders issued by the

[1] Brick and Clay Record, vol. 52, No. 4, Feb. 12, 1918.
[2] Fuel Facts, 2d ed. (revised), p. 46, December, 1918.

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Fuel Administration restricting the amount of fuel to be used by plants in this industrial group. The restrictive orders were made necessary in order that essential war activities might not suffer for an adequate supply of fuel. * * *

Present reports indicate that under the orders curtailing the fuel supply of this industry, which became effective April 13th last, there was effected 37 per cent reduction in the normal amount of coal consumed.

The figures announced are of particular interest, inasmuch as the curtailment orders were so worded that plants were permitted to burn their allotment of fuel at any time during the year, and many concerns chose to operate at full capacity until their fuel allowance was consumed, and then close down entirely. It is apparent, therefore, that had the war continued and the necessity for curtailment remained, the figures for the last half of the year would have revealed a very much greater saving. [Final figures, as shown by the table, estimate the saving at 4,000,000 tons.]

Coal consumed by manufacturers of clay products, 1915–1918, in short tons, showing results of curtailment orders of the United States Fuel Administration.[a]

State.	Annual average coal consumption, 1915–1917.	Coal consumed, first half of 1918.	Difference between average [coal] consumption, 1915–1917, and that used first half of 1918, considered as net result of curtailment order.
Alabama	85,516	25,592	17,166
Arizona	2,578	1,236	53
Arkansas	110,047	14,996	40,028
California	164,710	40,957	41,398
Colorado	53,766	21,388	5,495
Connecticut	15,565	3,016	4,766
District of Columbia	16,392	3,733	4,463
Delaware	6,642	1,917	1,404
Florida	2,640	75	1,245
Georgia	151,201	49,310	26,290
Idaho	2,559	1,442	b 162
Illinois	1,064,904	236,297	296,155
Indiana	591,451	189,370	106,355
Iowa	399,183	140,609	58,983
Kansas	218,757	54,179	55,199
Kentucky	133,298	40,588	26,061
Louisiana	14,223	4,989	2,123
Maine	14,006	3,588	3,415
Maryland	76,252	22,243	15,883
Massachusetts	12,829	2,316	4,099
Michigan	82,494	23,023	18,224
Minnesota	127,282	29,105	34,536
Mississippi	32,448	8,738	7,486
Missouri	314,051	113,103	43,922
Montana	25,148	11,445	1,129
Nebraska	36,459	6,977	11,253
New Hampshire	6,272	385	2,751
New Jersey	363,259	95,408	86,222
New Mexico	12,945	3,929	2,543
New York	190,750	31,171	64,204
North Carolina	68,801	22,871	11,529
North Dakota	22,068	8,314	2,720
Ohio	2,262,072	567,739	563,297
Oklahoma	87,331	40,394	3,271
Oregon	3,198	1,677	b 78
Pennsylvania	800,498	226,980	173,269
Rhode Island	3,332	1,000	666
South Carolina	24,824	5,231	7,181
South Dakota	1,481	1,010	b 270
Tennessee	236,279	103,556	14,584
Texas	236,869	102,388	16,046
Utah	17,609	7,702	1,103
Virginia	85,393	21,117	21,580
Vermont	362	.....	181
Washington	45,867	16,236	6,698
West Virginia	129,816	37,392	27,516
Wisconsin	43,631	9,807	12,008
Wyoming	7,438	713	3,006
	8,404,496	2,355,252	1,846,996

a Bureau of Statistics, United States Fuel Administration, 1918. b Excess.

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Coal consumed by manufacturers of clay products, 1915–1918, in short tons, showing result of curtailment orders of the United States Fuel Administration—Continued.

RECAPITULATION.

	Average annual consumption.	Average semi-annual consumption.	Percentage of total.	Six months' saving.	Estimated saving for year 1918.
Brick, terra cotta, roofing, floor and wall tile, and sanitary ware (50 per cent curtailment)	5,548,296	2,774,148	66	1,219,017	2,640,000
Hollow tile, draintile, and sewer pipe (25 per cent curtailment)	2,746,200	1,373,100	32.7	603,352	1,307,000
Stoneware (except chemical) (15 per cent curtailment)	110,000	55,000	1.3	24,627	53,000
	8,404,496	4,202,248	100.0	1,846,996	4,000,000

CLAY AGGREGATE FOR CONCRETE SHIPS.

One of the most interesting and perhaps important developments of the year was the experiment of building seagoing ships of concrete. In order to make the concrete as light in weight as possible, various light-weight materials including slag, volcanic scoria, and pumice were tried. An aggregate made of burnt clay was found to be the best substitute for stone and gravel in concrete, and its use reduced the weight of the concrete from 150 to 118 pounds per cubic foot. Burnt-clay aggregate in concrete has been used only in shipbuilding, but from the tests of the material in connection with that work there seems to be no reason to suppose that the light-weight aggregate may not find other uses where the weight of ordinary concrete is an objection, as in floors, roofs, and cars.

The following account of the development of this material, including tests of the compressive strength, permeability and absorptive properties of concrete made with clay aggregate, is taken from the Engineering News-Record of April 24, 1919:

HISTORY AND PROPERTIES OF LIGHT-WEIGHT AGGREGATES.

BURNT CLAY OR SHALE, PRODUCING MATERIAL FULL OF NONCONNECTING CELLS AND MAKING CONCRETE OF HIGH STRENGTH AND LIGHT WEIGHT, DEVELOPED BY GOVERNMENT'S CONCRETE-SHIP ENGINEERS.

Light-weight aggregate made from an artificially burnt shale or clay is now being used for the concrete on all of the Government concrete ships. The concrete so made, in rich mixtures and with a fine-ground cement, weighs from 100 to 118 pounds per cubic foot, and tests in compression from 3,500 to 5,500 pounds per square inch at the end of 28 days. Furthermore, it is impermeable, readily workable, and, so far as has been ascertained, has no defects not common to concrete with any of the more generally used aggregates. This artificial aggregate has been developed by the concrete ship section of the United States Emergency Fleet Corporation, but until now no definite statement of its method of manufacture or of its properties has been given out. Engineering News-Record is permitted here to make public the present knowledge of the material.

Early in the study of the concrete ship it became evident that to compete commercially with wood and steel the concrete must be lighter than the 150 pounds per cubic foot structural mixture commonly used. Naturally, low-weight concrete meant a low-weight aggregate. Many investigations were made into the possibilities of slag and various light, natural aggregates, such as volcanic scoria, pumice, etc., all of which are of a vesicular nature, that is, full of small nonconnecting cells, which reduce weight. In pursuance of these studies it was found that certain clays or shales could be burnt so as to produce a light-weight vesicular product similar in appearance

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and qualities to the volcanic basalts, but more uniform in character and therefore better fitted for aggregates.

Accordingly, experimental work was started at the Bureau of Standards in the early summer of 1918 on quantity production of this material. The first working plant was a down-draft beehive kiln near Birmingham, Ala., where enough aggregate was turned out to supply the 3,000-ton *Atlantus* launched in December at Brunswick, Ga. Experiments were also carried on in a Portland cement rotary kiln at Ragland, Ala., and initiated at a railroad tunnel kiln at Perth Amboy, N. J., local clays and shales being used at each, but neither progressed beyond the experimental stage. Later, however, two contracts were let for quantity production for the big concrete ships under way; one to the Atlas Portland Cement Co., which makes the aggregate in cement kilns at Hannibal, Mo., and one to the Los Angeles Pressed Brick Co., which made the aggregate in dome kilns formerly used for burning brick. Both plants are now producing aggregates, the Hannibal plant supplying the ships at Wilmington, N. C., Jacksonville, Fla., and Mobile, Ala., and the Los Angeles kilns those at San Diego and San Francisco. In all, 25,000 tons of the aggregate will be required for the present Government program.

The new light-weight aggregate, as has been stated, is an artificially burned clay or shale uniformly filled with small nonconnecting cells. Speaking nontechnically it is a bloated brick, that is, the basic clay or shale from which it is formed, when subjected to a temperature of about 1,800° to 2,000° in a kiln, becomes plastic and sears over on the surface, a coating being formed there which retains the gases generated by the decomposition, under heat, of the contained compounds. This expanding gas blows the brick or the clay ball full of holes and bloats it to several times its original size.

Various clays and shales are of the proper quality and consistency for such an aggregate. The material from which the aggregate is made should be rich in compounds of metallic oxides, carbon, sulphur, sodium, potassium, or other equivalent compounds, some of which, when the material is subjected to heat, will either act as a flux in reducing the more refractory compounds or will give off gas at the desired time, or both. The use of clay or shale containing a relatively high percentage of calcium carbonate or magnesium carbonate should be avoided, as such undesirable elements, after being subjected to a temperature sufficiently high to change their form, would be detrimental to the product. The ratio of the fluxing constituents to the nonfluxing constituents can vary within wide limits, but ratios indicating fusibility at comparatively low temperatures may be commercially preferable.

Such material is widely distributed, having been found in Alabama, New Jersey, Missouri, New York, and California, and used commercially in the production of aggregates in those localities. An analysis of a typical clay or shale of which such aggregate is made is as follows:

	Per cent.		Per cent.
SiO_2	60	CO_2	2
Fe_2O_3	8	Alkalies	3
Al_2O_3	19	Water	5
CaO	1		
MgO	1		100
SO_3	1		

Such composition is found both in shales and clays. Both can be used in the manufacture of the aggregate, although the process of manufacture is slightly different. Either one weighs about 100 pounds per cubic foot in its natural state.

In general, in the production of the aggregate, the raw shale or clay must first be reduced by means of suitable crushers or disintegrators to a fineness so that all of it will pass through about $\frac{3}{16}$-inch openings. The purpose of this reduction is to obtain uniform texture and to prevent striations and laminations, which might otherwise result in the finished material. It is then burned in a kiln, according to either the wet or dry process as noted hereinafter, is taken from the kiln either in large balls or in the bloated brick, and is then crushed to the required sizes for the aggregate which, in the concrete-ship work, is not larger than passing through a $\frac{1}{2}$-inch round opening.

The aggregate burned in the stationary brick kilns is prepared as an ordinary brick for the burning. Such a product used on the Brunswick ship was made at the brick plant of the Copeland-Inglis Shale Brick Co., at Alton, near Birmingham, Ala. This material was burned in an ordinary type of down-draft dome brick kiln. The raw material, which was a shale, was prepared as for common, stiff-mud brick, and after drying to a less degree than is the practice for the production of common brick, was placed in the kiln, set rather close in columns, leaving space for swelling, and fired

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rapidly. The resulting product was more or less oxidized on the surface, and lacked the uniformity possible by other methods of burning. However, most of the product was quite satisfactory. The bricks, when sufficiently cool, were taken from the kiln, crushed, and screened.

The coarse aggregate was that which passed the ½-inch screen and was retained on the $\frac{3}{16}$, the fine aggregate that passing the $\frac{1}{16}$-inch screen to dust. * * * Local coal was used for the fuel in the kilns.

While burning the aggregate at Alton, experiments were also made in burning the same material in a rotary kiln at the plant of the Coosa Portland Cement Co., at Ragland, Ala. In the experiments, the shale from Alton and the shale from the cement company's land were both used. There was practically no difference in the products of the two materials, neither was there much difference in the analysis of the shales. In this experiment the shale was prepared by passing it through Fuller mills and then directly to the kiln in the form of both a dry powder and a slurry. Bricks, also, were made at Alton and shipped to be burned in the rotary kiln with quite satisfactory results. From the experiment, though it was not extensive enough to establish the fact, it would seem that somewhat better results might be expected from the use of a slurry than from the use of a dry feed. Some very excellent material was produced during this experiment, made in an ordinary cement kiln 8 feet in diameter by 125 feet long, using powdered coal as fuel. None of this material was used in the ships.

Further experiments were made at certain other places, both with tunnel kilns and with ordinary brick kilns, but none of the material was used in practical work.

Later a contract was entered into with the Atlas Portland Cement Co. to produce light aggregates in its plant at Hannibal, Mo., using shale found on the property. The raw material here was reduced to a fineness of approximately 100 per cent through a 50-mesh screen, and introduced into a large cement rotary kiln in a dry state, with powdered coal as fuel. This burned ball coming through the rotary was passed directly into a crusher while hot and sorted at the distribution end of the kiln. Crushing the material while hot and malleable produced particles of a spheroid shape with few of the sharp corners which distinguish the cold-crushed material. In this product there is a rather large quantity of extra hard-burned small particles, which are screened out before the larger particles are crushed. These hard fines weigh considerably more than the more porous product, but on account of the expense of production they are being used in the ship work. As noted in the tables and descriptions further on, they tend to increase the weight of the concrete a few pounds over that of the concrete made from the brick aggregate. The product of the Hannibal mill is now being shipped to the Atlantic and Gulf yards.

Still later an agreement was made with the Los Angeles Pressed Brick Co. to produce the aggregate in semimuffle and downdraft kilns, using oil as fuel. In this plant the material is pugged and mixed with water and forced through brick machines and burned as ordinary brick. There is being produced here a remarkably light and satisfactorily strong material * * *

It is being used on the San Diego and San Francisco ships.

The aggregate as used in the concrete ships is as a rule being divided into two sizes, the coarse material that which passes through a screen having ½-inch round openings and is retained on the screen having $\frac{3}{16}$-inch round openings, and the fine material, that which passes through a screen having $\frac{1}{16}$-inch round openings. In the ships the concrete is mixed in the proportions of one part cement, two-third part fine aggregate, and one and one-third parts coarse aggregate, although in some of the yards these proportions have been changed to slightly different mixtures which are noticed in the various strength tests given herewith. The early specification for the concrete was that the 1:2/3:4/3 mixture with sufficient water to produce a consistency drop of 9 inches, shall develop in seven days a minimum strength of 2,500 pounds, using standard American Portland cement. In the ship the special fine-ground cement, passing 90 per cent through the 200-mesh screen, is being used. The tests, as given in the accompanying tables, indicate that the 2,500 pound would be a safe minimum for the seven-day test, with 4,000 or even 4,500 pounds per square foot for the 28-day test. The early specifications for the weight of the aggregate were that the coarse material should not weigh more than 37 pounds per cubic foot. This is somewhat lighter than the average material produced.

Tests are given in the various tables herewith.[1] Table I represents the mill test of the concrete aggregate made at Hannibal, mixed to a 1:2/3:1 proportion. These are compression tests on 6 by 12 inch cylinders and represent material shipped to Mobile, Jacksonville, and Wilmington. The screen analysis of only one of the

[1] The tables referred to contain so much detail as to make their publication in this report impracticable. The results of the tests are, however, summarized in the paragraphs that follow.

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aggregates is given, but this is fairly representative of the group. From this it will be seen that the fine aggregate made at Hannibal averages about 67 pounds per cubic foot in weight and the coarse aggregate about 43 pounds per cubic foot, that the 7-day compressive strength is about 2,500 pounds per cubic foot, the 28-day compressive strength averages 4,417 pounds for 61 tests, and that the weight of the concrete for the same number of tests is 114.2 pounds per cubic foot. The low compression for 28 days is 3,246 pounds and the high 5,397 pounds, with only two testing below 3,500 and eight above 5,000 pounds. The low weight for the wet concrete is 112 pounds and the high 117½ pounds.

Table II gives the result of cylinders taken from the actual pourings of the various Atlantic and Gulf ships of concrete made with the Hannibal aggregate. From these it will be seen that the 28-day test of a 1:1:1 concrete made up of the aggregates of the sizes noted before averages well above 5,000 pounds per square inch, and that the weight is somewhat higher than the weight of the mill-tested concrete of the 1:2/3:4/3 mixture, running around 116 pounds per cubic foot. This, however, is the weight immediately after pouring, and other tests have shown that this decreases 3 or 4 pounds in the 28-day test. Table III shows the tests of various proportions and various ages of the dome-kiln aggregate used in the *Atlantus* at Brunswick, Ga.

The strengths are not quite as high as the others given, but the weights are about the same. * * * In experimental mixtures not noted here the material dropped as low as 92 pounds per cubic foot in weight, and averaged below 100 pounds. Tests on the concrete as poured in the ships show that while the weight is not quite so low it is somewhat less than with the eastern aggregates and the strength is satisfactory.

There has not been sufficient time to make long-time tests of the light-weight concrete, but a few such tests * * * show values as high as 7,200 pounds at three months, and for the standard consistency of the other tests a strength of 6,483 pounds for the same period.

Some concern is occasionally expressed as to the permeability of a concrete made with this material. A number of tests have been made, and they all show that such a concrete is as low in absorption and in permeability as concrete made with an apparently more dense aggregate. The material is not porous. While full of holes, it must be remembered that they are nonconnecting holes, so that there is no reason why water should pass through such a concrete, assuming that the aggregate itself is of a dense material. Very few strength tests on the aggregate itself have been made. Recent tests at the University of Pennsylvania laboratory show that in 1-inch cubes it has an average compressive strength of about 1,500 pounds per square inch, with values in test ranging from 1,000 to 2,500 pounds.

Commercial production of the aggregate except for the Government ships has not been started, though there are prospects that one or both of the Government contractors will continue production after the ship requirements are satisfied. There is a company in Kansas City, under the direction of Stephen J. Hayde, which is manufacturing a somewhat similar product known as haydite. This material was used in the concrete superstructure of the freight car recently exhibited in Chicago. Haydite was developed some years ago as the aggregate for sand-lime brick and is produced in a vertical kiln.

The technique of the manufacture of the aggregate is necessarily complicated, as the value of the resulting product depends so much on the quality and moisture content of the raw material, the nature of the preliminary treatment, the degree of heat, and many other details. There is no claim that perfection has been reached in the brief time in which experiments and quantity production have been under way, but the aggregate is uniform and satisfactory in quality and there is every hope that its commercial manufacture is possible. Costs to-day are not consistent, and are not therefore of much use to those contemplating the use of the aggregate for structural purposes. It seems, however, that the aggregate should be produced at the mill for $3 or $4 per cubic yard, which will weigh in the crushed state * * * in the ball or brick, uncrushed, about 60 pounds per cubic foot.

The studies, tests, and production of this aggregate have all been carried out under the direction of Rudolph J. Wig, head of the concrete-ship section of the Emergency Fleet Corporation, with C.W. Boynton and W. D. Richardson, specialists, in immediate charge of the work.

Credit should also be given to A. V. Bleininger, ceramic chemist of the Bureau of Standards, for laboratory burns of various clays to determine suitability for the purpose.

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ACKNOWLEDGMENTS.

The writer again desires to thank the clay workers of the country for their cooperation, without which this report would be impossible, and also to express his thanks to the clay-working press for its support and appreciation, and to the officials who have supplied information concerning the building operations of the larger cities of the country.

PRODUCTION.

Every State is a producer of clay wares. A small production was reported from the District of Columbia and from Porto Rico. In Nevada and Rhode Island there was not a sufficient number of producers reporting to permit the publication of State totals without disclosing confidential information, so that statistics for these States have been combined with those of contiguous States.

No returns are received from the clay workers of the Philippine Islands by the United States Geological Survey, but the output of clay products in the islands in 1918 is reported by the Bureau of Insular Affairs, of the War Department, to have been valued at $455,000. This valuation, which was a slight increase over that of 1917, is not included in the production of the United States.

The value of the clay products in the United States from 1895 to 1918 is shown in figure 96 (p. 868).

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Value of clay products sold in the United States in 1917 and 1918, with increase or decrease.

State.	1917						1918						Increase or decrease, 1918.	
	Rank of State.	Number of firms reporting sales.	Brick and tile.	Pottery.	Total.	Percentage of total value.	Rank of State.	Number of firms reporting sales.	Brick and tile.	Pottery.	Total.	Percentage of total value.	Value.	Per cent.
Alabama	22	53	$1,741,154	$18,731	$1,759,885	0.8	18	49	$2,143,780	$15,324	$2,159,104	1.0	+ $399,219	+ 22.7
Arizona	44	11	135,474	.....	135,474	.1	43	11	133,381	1,181	134,562	.0	− 912	− .7
Arkansas	30	22	672,766	(a)	a672,766	a .3	29	20	679,183	(a)	a679,183	a .3	+ 6,417	+ 1.0
California	11	74	4,212,974	613,151	4,826,125	2.1	11	68	3,665,290	663,930	4,329,220	2.0	− 496,905	− 10.3
Colorado	17	54	2,132,761	158,093	2,290,854	1.0	17	47	2,089,889	209,559	2,299,448	1.0	+ 8,594	+ .3
Connecticut and Rhode Island	23	35	1,705,013	(b)	a1,705,013	a .7	25	33	1,423,782	(b)	a1,423,782	a .6	− 281,231	− 16.5
Delaware	42	11	197,310	.....	197,310	.1	42	9	164,486	.....	164,486	.1	− 32,824	− 16.6
District of Columbia	43	5	154,242	6,000	160,242	.1	46	5	61,606	5,000	66,606	.0	− 93,636	− 58.4
Florida	40	16	224,606	4,800	229,406	.1	39	19	181,339	(a)	a181,339	a .1	− 48,067	− 21.0
Georgia	16	62	2,414,368	12,303	2,426,671	1.0	14	64	2,944,869	19,837	2,964,706	1.3	+ 538,035	+ 22.2
Idaho and Nevada	41	19	198,606	.....	198,606	.1	41	13	173,611	.....	173,611	.1	− 24,995	− 12.6
Illinois	4	207	15,619,491	1,571,262	17,190,753	7.4	4	168	10,690,042	1,769,735	12,459,777	5.6	− 4,730,976	− 27.5
Indiana	7	178	7,828,251	1,890,501	9,718,752	4.2	8	157	6,175,417	1,775,509	7,950,926	3.6	− 1,767,826	− 18.2
Iowa	9	137	7,535,313	4,900	7,540,213	3.2	10	123	5,313,394	(a)	a5,313,394	a2.4	− 2,226,819	− 29.5
Kansas	14	39	2,695,722	.....	2,695,722	1.2	19	31	2,064,320	.....	2,064,320	.9	− 631,202	− 23.4
Kentucky	10	55	4,883,867	153,769	5,037,636	2.2	9	47	6,007,032	165,522	6,172,554	2.8	+ 1,134,918	+ 22.5
Louisiana	35	21	440,053	7,888	447,941	.2	35	22	450,556	7,889	458,445	.2	+ 10,504	+ 2.3
Maine	34	35	531,870	(a)	a531,870	a .2	33	23	500,725	.....	500,725	.2	− 31,145	− 5.9
Maryland	15	36	2,135,184	332,954	2,468,138	1.1	16	34	2,378,699	342,416	2,721,115	1.2	+ 252,977	+ 10.2
Massachusetts	19	55	1,720,988	250,992	1,971,980	.8	24	44	1,327,079	166,686	1,493,765	.7	− 478,215	− 24.3
Michigan	12	69	2,846,264	1,187,981	4,034,245	1.7	12	61	1,708,736	1,976,436	3,685,172	1.7	− 349,073	− 8.7
Minnesota	18	52	2,197,664	(a)	a2,197,664	a .9	22	46	1,503,659	(a)	a1,503,659	a .7	− 694,005	− 31.6
Mississippi	33	42	535,584	18,001	553,585	.2	32	37	513,441	15,040	528,481	.2	− 25,104	− 4.5
Missouri	6	77	10,281,302	10,675	10,291,977	4.4	7	65	9,146,701	8,387	9,155,088	4.1	− 1,136,889	− 11.0
Montana	32	22	580,230	500	580,730	.3	34	17	464,715	.....	464,715	.2	− 116,015	− 20.0
Nebraska	27	37	1,160,508	(a)	a1,160,508	a .5	28	36	789,612	(a)	a789,612	a .4	− 370,896	− 32.0
New Hampshire	36	17	411,876	(a)	a411,876	a .2	36	12	235,219	(a)	a235,219	a .1	− 176,657	− 42.9
New Jersey	3	142	9,998,389	12,535,843	22,529,232	9.7	3	132	8,170,402	12,570,842	20,741,244	9.3	− 1,787,988	− 7.9
New Mexico	39	7	257,875	.....	257,875	.1	38	6	183,607	10,926	194,533	.1	− 63,342	− 24.6
New York	5	167	7,351,582	4,076,817	11,428,399	4.9	6	141	4,845,482	6,047,472	10,892,954	4.9	− 535,445	− 4.7
North Carolina	24	114	1,654,832	7,475	1,662,307	.7	21	93	1,581,248	8,260	1,589,508	.7	− 72,799	− 4.4
North Dakota	38	9	294,016	.....	294,016	.1	40	6	176,843	.....	176,843	.1	− 117,173	− 39.9
Ohio	1	470	30,603,337	21,353,706	51,957,043	22.3	1	424	27,119,526	25,779,654	52,899,180	23.8	+ 942,137	+ 1.8
Oklahoma	21	27	1,857,546	.....	1,857,546	.8	23	27	1,496,490	.....	1,496,490	.7	− 361,056	− 19.4
Oregon	37	36	331,546	(a)	a331,546	a .1	37	32	232,564	(a)	a232,564	a .1	− 98,982	− 29.9

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Pennsylvania	2	315	35,548,161	3,194,944	38,743,105	16.7	2	288	37,023,783	3,443,321	40,467,104	18.2	+ 1,723,999	+ 4.4
Porto Rico	48	4	3,374	(a)	a3,374	.....	48	7	11,722	(a)	a11,722	.....	+ 8,348	+247.4
South Carolina	31	34	654,613	8,188	662,801	.3	31	28	600,093	5,675	605,768	.3	− 57,033	− 8.6
South Dakota	47	4	47,213	.....	47,213	.....	47	3	32,161	.....	32,161	.....	− 15,052	− 31.9
Tennessee	20	67	1,569,146	400,080	1,969,226	.8	15	47	2,409,476	382,391	2,791,867	1.3	+ 822,641	+ 41.8
Texas	13	82	3,358,913	92,893	3,451,806	1.5	13	76	2,958,328	68,231	3,026,559	1.4	− 425,247	− 12.3
Utah	29	19	789,844	7,333	797,177	.3	30	18	610,288	(a)	a610,288	a .3	− 186,889	− 23.4
Vermont	46	4	98,344	.....	98,344	.....	45	4	87,609	.....	87,609	.....	− 10,735	− 10.9
Virginia	25	48	1,625,912	32,130	1,658,042	.7	20	44	1,636,873	29,981	1,666,854	.8	+ 8,812	+ .5
Washington	26	33	1,532,043	996	1,533,039	.7	26	32	1,274,708	(a)	a1,274,708	a .6	− 258,331	− 16.9
West Virginia	8	57	2,364,165	7,243,900	9,608,065	4.1	5	56	2,295,471	8,693,206	10,988,677	5.0	+ 1,380,612	+ 14.4
Wisconsin	28	64	1,114,121	8,000	1,122,121	.5	27	51	874,172	(a)	a874,172	a .4	− 247,949	− 22.1
Wyoming	45	9	106,838	.....	106,838	.....	44	7	110,091	.....	110,091	.....	+ 3,253	+ 3.0
Undistributed	.....	.....	.....	957,716	957,716	.4	.....	.....	.....	1,040,541	1,040,541	.5	+ 82,825	+ 8.6
	.....	3,153	176,350,251	56,162,522	232,512,773	.....	.....	2,783	156,661,700	65,222,951	221,884,651	.....	−10,628,122	− 4.6
Percentage of total	.....	.....	75.8	24.2	100.0	.....	.....	.....	70.6	29.4	100.0	.....	.....	.....

a Pottery included in "Undistributed."

b Produced by Connecticut alone and included in "Undistributed."

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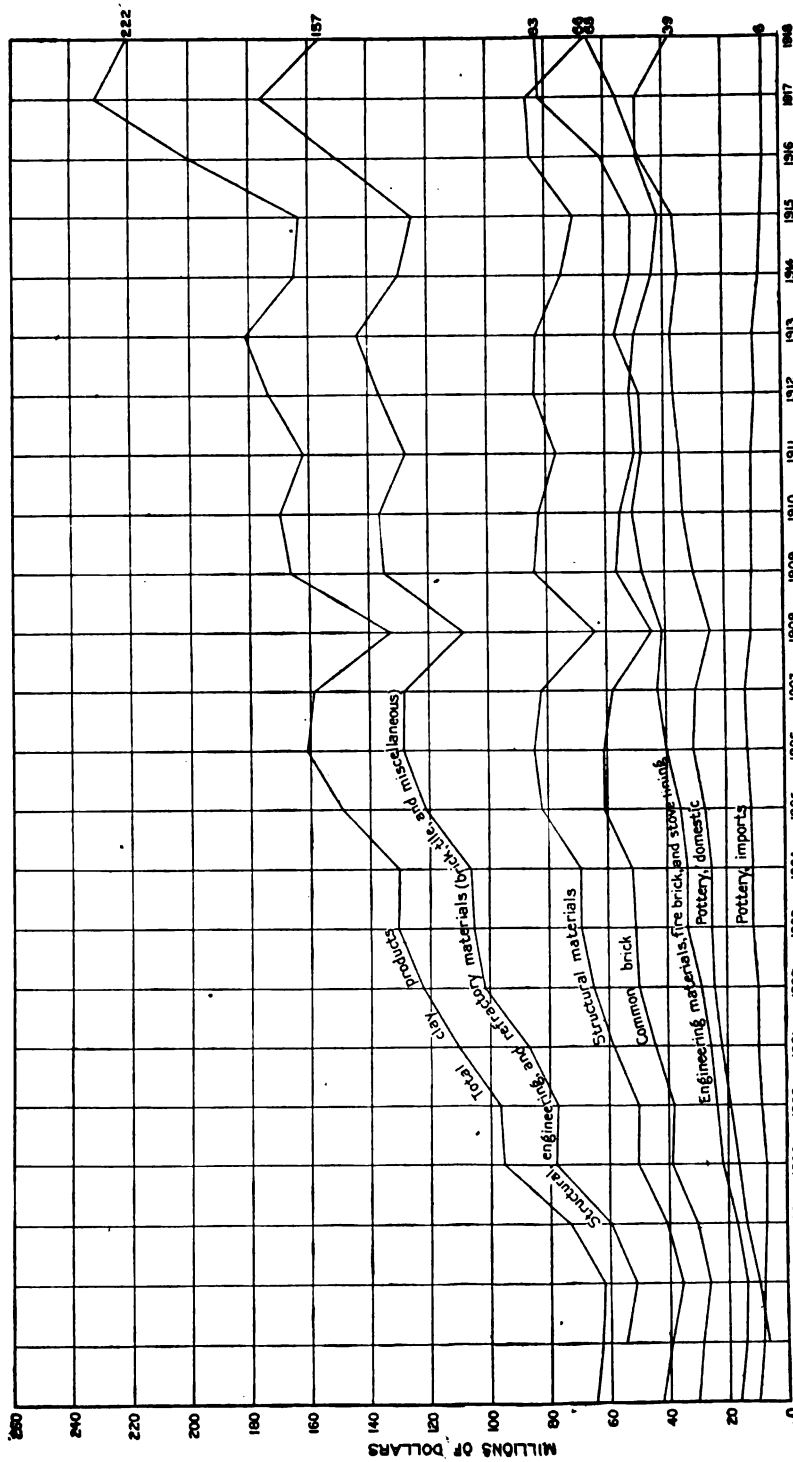

FIGURE 96.—Value of clay products sold in the United States, 1895–1918.

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The value of brick and tile products as classified in this report constituted in 1918 a little less than three-fourths and that of the pottery a little more than one-fourth of the total. The total value of clay products marketed in 1918 showed a large decrease, which indicates that there was more or less stagnation in the industry. This condition, unfortunately, appears to have been true, as 34 of the 48 States reported decrease in value of output and 14 showed increase, Pennsylvania, West Virginia, Kentucky, Ohio, and Tennessee leading in increase in the order named. Pennsylvania and Kentucky owed their total increase to the increase in the value of fire brick and West Virginia and Ohio owed their increase to the value of pottery; in Tennessee the increase was due to the growth of the common brick and sewer-pipe industries and the manufacture on a large scale of acid-proof spiral rings for Government use.

Ohio has been the leading State in the value of clay products since the statistics were first compiled by the Geological Survey in 1894. The value of its output has always greatly exceeded that of the second State, Pennsylvania. In 1918 the value of Ohio's clay products was greater by $12,432,076, or 31 per cent, than that of Pennsylvania. In the first 10 States in value of output West Virginia rose from eighth to fifth place, and Kentucky from tenth to ninth; New York fell from fifth to sixth, Missouri from sixth to seventh, Indiana from seventh to eighth, and Iowa from ninth to tenth; Alabama rose from twenty-second to eighteenth place; Kansas fell from fourteenth to nineteenth, Massachusetts from nineteenth to twenty-fourth, and Minnesota from eighteenth to twenty-second; Tennessee rose from twentieth to fifteenth and Virginia from twenty-fifth to twentieth. Other changes in rank of States in value of output were insignificant. The first five States in value of output reported wares valued at $137,555,982, or 62 per cent of the total, compared with $141,848,532, or 61 per cent of the total, in 1917. The first 10 States reported wares valued at $177,040,898, or 80 per cent of the total, and the first 10 States in 1917 reported wares valued at $184,045,175, or 79 per cent of the total.

Twenty-five States that reported increase in value in 1917 decreased in 1918; 11 States increased and 9 decreased in both years; and only 3 States that decreased in 1917 increased in 1918, namely, Porto Rico, Tennessee, and Virginia.

Value of the clay products of the United States in 1917 and 1918, and increase or decrease in 1918, by products.

Product.	1917	1918	Increase or decrease in 1918.	
			Value.	Per cent.
Common brick	$47,936,344	$38,782,458	−$9,153,886	−19.1
Vitrified brick or block	10,664,560	7,145,359	− 3,519,201	−33.0
Face brick	10,391,368	6,095,120	− 4,296,248	−41.3
Fancy or ornamental brick	192,072	73,086	− 118,986	−61.9
Enameled brick	889,899	480,772	- 409,127	−46.0
Drain tile	11,008,163	8,196,199	− 2,811,964	−25.5
Sewer pipe	17,307,211	15,333,673	− 1,973,538	−11.4
Architectural terra cotta	6,173,550	2,658,693	− 3,514,857	−56.9
Fireproofing and hollow building tile	13,255,433	13,037,102	− 218,331	− 1.6
Tile, not drain	6,821,221	5,082,069	− 1,739,152	−25.5
Stove lining	619,882	673,953	+ 54,071	+ 8.7
Fire brick	42,501,669	51,647,639	+ 9,145,970	+21.5
Miscellaneous	8,588,879	7,455,577	− 1,133,302	−13.2
Total brick and tile	176,350,251	156,661,700	−19,688,551	−11.2
Total pottery	56,162,522	65,222,951	+ 9,060,429	+16.1
Grand total	232,512,773	221,884,651	−10,628,122	− 4.6

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This table shows the general decrease in the value of clay products in 1918, as compared with 1917; 10 brick and tile and the miscellaneous products decreased, and only two brick and tile products—the refractories—and pottery increased. Of the structural materials common brick showed the largest decrease, $9,153,886, or 19 per cent, and of the engineering materials vitrified brick showed the largest decrease, $3,519,201, or 33 per cent. The largest proportionate decrease was in fancy or ornamental brick—nearly 62 per cent. This, however, is an unimportant branch of the industry, its value constituting in 1918 only 0.03 per cent of the value of clay products, or 0.05 per cent of the value of brick and tile products. Of the important structural materials architectural terra cotta showed the largest proportionate decrease—nearly 57 per cent. Fire brick, which has been rapidly advancing in importance and value in recent years, made another large increase in 1918, though not so great either actually or proportionately as in 1917.

In 1917 eight brick and tile and miscellaneous produots increased and four decreased. The four to decrease in that year were common brick, vitrified brick, face brick, and architectural terra cotta. The net increase in 1917 was: Brick and tile $23,676,658, or nearly 16 per cent; pottery, $7,945,280, or 16 per cent; total increase, $31,621,938, or nearly 16 per cent.

Clay products sold in the United States, 1909–1918.

Year.	Number of firms reporting sales.	Common brick.			Vitrified brick or block.		
		Quantity (thousands).	Value.	Average price per thousand.	Quantity (thousands).	Value.	Average price per thousand.
1909	5,068	9,791,870	$57,251,115	$5.85	1,023,654	$11,269,586	$11.01
1910	4,915	9,221,517	55,219,551	5.99	968,000	11,004,666	11.37
1911	4,628	8,475,277	49,885,262	5.89	948,758	11,115,742	11.72
1912	4,284	8,555,238	51,796,266	6.05	911,869	10,921,575	11.98
1913	4,065	8,088,790	50,134,757	6.20	958,680	12,138,221	12.66
1914	3,860	7,146,571	43,769,524	6.12	931,324	12,500,866	13.42
1915	3,636	6,851,099	42,145,292	6.15	953,335	12,230,899	12.83
1916	3,412	7,304,202	49,357,411	6.68	941,553	12,236,890	13.00
1917	3,153	5,864,909	47,936,344	8.17	706,934	10,664,560	15.09
1918	2,783	3,556,519	38,782,458	10.90	402,816	7,145,359	17.74

Year.	Face brick.			Fancy or ornamental brick (value).	Enameled brick (value).	Fire brick [a] (value).	Stove lining (value).	Draintile (value).
	Quantity (thousands).	Value.	Average price per thousand.					
1909	816,164	$9,712,219	$11.90	$174,073	$993,902	$16,620,695	$423,583	$9,799,158
1910	697,857	8,590,057	12.31	179,505	832,225	18,111,474	503,806	10,389,822
1911	724,911	8,648,877	11.93	177,015	1,038,865	16,074,686	614,116	8,826,314
1912	814,007	9,455,297	11.62	225,367	1,027,314	17,877,629	516,874	8,010,250
1913	827,665	9,614,138	11.62	109,703	1,225,708	20,627,122	535,667	8,558,320
1914	810,395	9,289,623	11.46	124,459	1,075,026	16,427,547	520,585	8,522,039
1915	855,668	9,535,536	11.14	109,425	835,808	18,839,931	459,341	8,879,264
1916	1,002,762	11,464,614	11.43	109,072	827,443	24,436,873	601,776	10,083,647
1917	757,618	10,391,368	13.72	192,072	889,899	42,501,669	619,882	11,008,163
1918	356,394	6,095,120	17.10	73,086	480,772	51,647,639	673,953	8,196,199

[a] Include from 1910 to 1915 silica brick, as follows: 1910, $3,289,028; 1911, $2,520,816; 1912, $2,923,174; 1913, $3,815,806; 1914, $2,951,525; and 1915, $3,039,809.

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Clay products sold in the United States, 1909–1918—Continued.

Year.	Sewer pipe (value).	Architectural terra cotta (value).	Hollow building tile and fireproofing (value).	Tile, not drain (value).	Miscellaneous (value).	Total brick and tile (value).a	Pottery.	Grand total.a
1909.....	$10,322,324	$6,251,625	$4,466,708	$5,291,963	$2,694,821	$135,271,772	$31,049,441	$166,321,213
1910.....	11,428,696	6,976,771	5,110,597	5,240,644	2,743,482	136,331,296	33,784,678	170,115,974
1911.....	11,454,616	6,017,801	5,660,172	5,356,184	2,847,971	127,717,621	34,518,560	162,236,181
1912.....	12,147,677	8,580,436	7,174,148	5,809,495	2,764,783	136,307,111	36,504,164	172,811,275
1913.....	14,872,103	7,733,306	8,620,216	6,109,180	3,018,316	143,296,757	37,992,375	181,289,132
1914.....	14,014,767	6,087,652	8,385,337	5,705,583	3,165,814	129,588,822	35,398,161	164,986,983
1915.....	11,259,349	4,796,062	7,800,938	5,186,055	3,716,944	125,794,844	37,325,388	163,120,232
1916.....	13,577,006	6,466,336	9,942,912	6,475,464	7,094,149	152,673,593	48,217,242	200,890,835
1917.....	17,307,211	6,173,550	13,255,433	6,821,221	8,588,879	176,350,251	56,162,522	232,512,773
1918.....	15,333,673	2,658,693	13,037,102	5,082,069	7,455,577	156,661,700	65,222,951	221,884,651

a Include from 1910 to 1915 silica brick, as follows: 1910, $3,289,028; 1911, $2,520,816; 1912, $2,923,174; 1913, $3,815,806; 1914, $2,951,525; and 1915, $3,039,869.

The growth of the clay-working industries in the United States during the last 10 years is shown in this table. The total value of the products ranged from $162,236,181 in 1911 to $232,512,773 in 1917, an increase of $70,276,592, or 43 per cent. The value in 1918 was exceeded only by that of 1917 and was greater by $55,563,438, or 33 per cent, than that of 1909. Compared with 1913, the last year of normal conditions, the value in 1918 was greater by $40,595,519, or 22 per cent.

The output of common brick in the period covered ranged from 9,791,870,000 in 1909 to 3,556,519,000 in 1918, a decrease of 6,235,351,000 brick, or 64 per cent. The value of common brick ranged from $57,251,115 in 1909 to $38,782,458 in 1918, a decrease of $18,468,657, or 32 per cent. On the other hand, the average price per thousand increased from $5.85 in 1909 to $10.90 in 1918, thus nearly doubling. Compared with 1913, when the output of common brick was 8,088,790,000 brick, valued at $50,134,757, there was a decrease in 1918 of 4,532,271,000 brick, or 56 per cent, in quantity and of $11,352,299, or 23 per cent, in value. The output in 1918 was the smallest recorded by the Geological Survey and the value in 1918 was the smallest in many years. The maximum output of common brick recorded by the Geological Survey was 10,027,039,000 brick in 1906, and the maximum value of this kind of brick was $61,394,383 in 1905.

Vitrified brick or block reached its maximum output in 1909 and its maximum value in 1914. The output in 1918 was less than the maximum by 620,838,000 brick or block, or 61 per cent, and the value was less by $5,355,507, or 43 per cent. The average price per thousand in 1918 was the highest recorded; it was $2.65 higher than that of 1917 and $6.73 higher than that of 1909.

Face brick reached its maximum output and value in 1916 and, like common brick, decreased in output and value in both 1917 and 1918. The output in 1918 was less than that of the maximum by 646,368,000 brick, or 64 per cent, and the value was less by $5,369,494, or 47 per cent. The average price per thousand in 1918 was $3.38 higher than the previous high average (in 1917).

Fancy or ornamental brick, which has on the whole been declining in value, reached its minimum value in 1918 and was less by $100,987, or 58 per cent, than that of 1909.

Enameled brick, after increasing in value in 1917, showed a considerable decrease in 1918. It reached its maximum value in 1913.

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Since that time, with the exception of 1917, it has steadily declined in value. Its value in 1918 was less than that of the maximum by $744,936, or 61 per cent.

Fire brick was the only brick and tile product to reach its maximum value in 1918. Fire brick has increased in value and importance almost steadily for many years, the value in 1918 being greater by $34,836,323, or 207 per cent, than that of 1913.

Draintile reached its maximum value in 1917. The value in 1918 was the smallest since 1912.

Sewer pipe reached its maximum value in 1917. Its value in 1918 was exceeded in only one year, 1917, and it was greater by $461,570, or 3 per cent, than in 1913 and by $5,011,349, or 49 per cent, than in 1909.

Architectural terra cotta reached its maximum value in 1912. Its value in 1918 was less than the maximum by $5,921,743, or 69 per cent, and was the lowest value for many years.

Hollow building tile and fireproofing reached its maximum value in 1917. Its value in 1918 was slightly less than the maximum and was greater than the value in 1909 by $8,570,394, or 192 per cent.

Tile, not drain, reached its maximum value in 1917 after an almost steady rise for nine years. Its value in 1918 was the smallest since 1908, but was larger than in any year prior to 1909.

The value of brick and tile products ranged from $125,794,844 in 1915 to $176,350,251 in 1917. The value in 1918, though much smaller than that of 1917, was exceeded in that year only and was considerably greater than that in any other year within the decade. Pottery has made wonderful progress, its value increasing almost steadily from $31,049,441 in 1909 to $65,222,951 in 1918, an increase of $34,173,510, or 110 per cent.

The value of the clay products of the United States by varieties of ware is shown in the following table. The classifications there given are not all exact, but they are as definite as it is possible to make them from the data on hand. For instance, under "fire brick" are included all material reported as such by the producers and all grades of fire brick, from those of the highest refractoriness to those which sell at a low price and can have but little value as refractory material. On the other hand, the item "cooking ware, nonrefractory," possibly does not include all the ware used for that purpose. The table is interesting in that it shows in a general way and on broad lines the value of refractory and nonrefractory wares. The details of this table, where they differ from the tables showing the value of the brick and tile and pottery products, are derived from the miscellaneous columns of those tables. Only values are given, because for many products no data of quantity are available. In fact, for some wares, notably pottery, there is no satisfactory unit of quantity. Therefore increases during the last year or two caused by the increased cost of production do not necessarily represent proportionate increases in output. In fact, as shown by other tables in this report, the quantity of some wares decreased in greater proportion than the value on account of the higher prices received.

It is not possible to draw a hard and fast line between refractory and nonrefractory wares, but the classification is based on the generally accepted use of those terms. The rapid rise in the value of refractory wares, especially fire brick, glass-house refractories, and chemical pottery, may be ascribed to the war, as those materials

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are used, either directly or indirectly, in the manufacture of munitions or in the field and in the naval establishment. The most striking developments indicated in the nonrefractory wares are the great increase in the value of fire-proofing, hollow building tile or block, and porcelain electrical supplies and the decrease in value of common building brick.

An inspection of this table shows that, compared with 1913, the latest year of normal conditions, the value of clay products decreased in 1914, owing to the unsettled conditions brought about by the war. Of this decrease, however, less than one-fourth was in the refractory wares. In 1915 the nonrefractories continued to decrease, not having yet recovered from the demoralization caused by the outbreak of the war, but the refractories, owing to large contracts placed by foreign powers in this country, made a considerable increase—$3,268,290, or 17 per cent. In 1916, when the United States was in a highly prosperous condition, having recovered from the first shock of the war, nearly all branches of the industries showed great progress, refractory wares increasing in value $8,757,851, or 40 per cent, and the nonrefractory wares increasing $29,012,752, or nearly 21 per cent. In 1917 and 1918, with our Nation at war and the demand for munitions at the maximum, refractory wares increased $19,399,923, or 63 per cent, in 1917, and $9,574,254, or 19 per cent, in 1918. The nonrefractory products increased in value in 1917 only $12,222,015, or 7 per cent, and in 1918 decreased in value $20,202,376, or 11 per cent. To show further the increasing importance of the refractory products, it should be noted that the percentage of their value to the total value increased from 12.4 per cent in 1913 and 11.4 per cent in 1914, to 21.6 per cent in 1917, and to 26.9 in 1918.

Value of refractory and nonrefractory clay products of the United States, 1913–1918.

Class.	1913	1914	1915	1916	1917	1918
Refractory:						
Fire brick, including refractory block or tile, boiler and locomotive tile and tank blocks, and similar refractory products	$16,811,316	$13,476,022	$15,800,062	$24,436,873	$42,501,669	$51,647,639
Other fire brick, including some special shapes	134,635	115,144	121,747	311,052	473,713	404,657
Stove lining	535,667	520,585	459,341	601,776	619,882	673,953
Zinc retorts	(a)	576,655	823,545	1,553,691	1,514,027	1,181,334
Glass melting pots and other glasshouse refractories. (Special effort to collect statistics of these products from the consumer manufacturing for his own use was not made prior to 1915)	568,603	498,096	719,889	1,989,754	3,179,336	2,791,908
Gas retorts	65,846	41,372	23,835	35,821	(b)	(b)
Charcoal furnaces (portable)	37,217	36,243	32,865	27,280	40,568	34,552
Muffles, scorifiers, assay supplies and crucibles. (Other crucibles are included with chemical porcelain and chemical stoneware)	63,869	67,367	98,105	364,563	178,941	152,222
Saggers. (Prior to 1917 statistics for saggers were not collected from the sagger consumer manufacturing for his own use)	(b)	(b)	(b)	34,476	122,000	593,623
Chemical porcelain and chemical stoneware	c 224,894	c 246,918	c 620,401	1,054,061	1,099,432	1,769,710

a Reported by one producer only for 1913, and included with "Undistributed" refractory products. Statistics for zinc retorts were not collected prior to 1914.

b Reported by less than 3 producers. Included in "Undistributed" refractory products.

c Chemical porcelain and chemical stoneware, statistics for which were not separately collected prior to 1916, were probably partly reported under stoneware and yellow and Rockingham ware in 1913, 1914, and 1915.

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Value of refractory and nonrefractory clay products of the United States, 1913–1918—Contd.

Class.	1913	1914	1915	1916	1917	1918
Refractory—Continued.						
Mantle, rings, and special ware for gas lighting and heating, including magnesia ware and refractory procelain for electric ranges and heaters	(a)	(a)	$172,261	$220,849	$247,997	$247,207
Potters' supplies. (Pins, stilts, and spurs)	$125,987	$130,740	126,780	188,643	224,343	275,545
Undistributed	148,116	132,031	22,288	.....	16,854	20,666
	[b]22,531,956	[b]18,792,698	[b]22,060,988	30,818,839	50,218,762	59,793,016
Nonrefractory:						
Common brick	50,134,757	43,769,524	42,145,292	49,357,411	47,936,344	38,782,458
Vitrified brick or block	12,138,221	12,500,866	12,230,899	12,236,890	10,664,560	7,145,359
Face brick	9,614,138	9,289,623	9,535,536	11,464,614	10,391,368	6,095,120
Fancy or ornamental brick	109,703	124,459	109,425	109,072	192,072	73,086
Enameled brick	1,225,708	1,075,026	835,808	827,443	899,899	480,772
Draintile	8,558,320	8,522,039	8,879,264	10,083,647	11,008,163	8,196,199
Sewer pipe	14,872,103	14,014,767	11,259,349	13,577,006	17,307,211	15,333,673
Architectural terra cotta	7,733,306	6,087,652	4,796,062	6,466,336	6,173,550	2,658,693
Fireproofing and hollow building tile or block	8,620,216	8,385,337	7,800,938	9,942,912	13,255,433	13,037,102
Silo tile or block	138,263	(c)	(c)	(c)	(c)	(c)
Conduits	(d)	(d)	(d)	(d)	1,227,668	354,601
Roofing tile	1,130,286	1,043,020	891,150	914,240	871,872	729,981
Floor tile	2,483,082	881,362	912,180	1,438,231	1,325,516	1,075,474
Ceramic mosaic tile	(e)	1,520,739	1,185,787	1,308,861	1,481,505	956,456
Faience tile	731,820	675,615	635,073	814,077	1,007,005	724,734
Wall tile	1,763,992	1,584,847	1,561,865	2,000,055	2,135,323	1,595,424
Zinc condensers	(f)	176,591	260,436	512,453	496,691	408,794
Chemical or acid-proof brick block and tile, cylinders, rings, and other forms of tower packing used in the manufacture of acids at nitrate plants, and in petroleum refineries	(g)	(g)	(g)	(g)	(g)	764,588
Red earthenware	1,000,529	1,059,904	1,072,061	1,156,351	1,065,185	906,861
Stoneware and yellow and Rockingham ware	3,683,567	3,349,801	3,575,603	3,696,288	3,865,825	4,454,164
White ware, including C. C. ware, white granite, semiporcelain ware, and semivitreous porcelain ware	15,066,811	14,968,079	15,324,242	18,191,390	20,920,469	25,305,926
China, bone china, delft and belleek ware	2,424,060	2,384,686	2,330,156	3,478,372	4,805,906	6,307,349
Sanitary ware	8,214,838	7,874,269	7,993,216	11,111,417	12,636,217	11,241,138
Porcelain electrical supplies	5,737,741	4,130,270	4,671,202	7,034,420	9,451,586	12,505,970
Turpentine cups	(d)	(d)	(d)	284,218	(d)	25,289
Art pottery	400,244	374,113	446,457	619,558	870,229	722,586
Tobacco pipes	62,490	30,247	35,248	44,921	72,827	66,459
Hardware supplies and trimmings and door knobs	86,064	69,959	59,297	78,168	43,275	(d)
Toy marbles	57,000	66,325	63,948	75,304	77,243	(d)
Cooking ware, including porcelain cooking utensils (other cooking ware probably is included under stoneware)	(d)	(d)	376,532	478,805	316,991	425,822
Miscellaneous. (Mostly nonrefractory) [h]	2,769,917	2,235,665	2,072,218	2,769,536	1,804,078	1,717,557
	158,757,176	146,194,285	141,059,244	170,071,996	182,294,011	162,091,635
Grand total [b]	181,289,132	164,986,983	163,120,232	200,890,835	232,512,773	221,884,651

[a] Reported by less than 3 producers. Included in "Undistributed" refractory products.
[b] Includes silica brick as follows: 1913, $3,815,806; 1914, $2,951,525; and 1915, $3,039,869.
[c] All silo tile or block was reported under fireproofing in 1914, 1915, 1916, 1917, and 1918.
[d] Included in "Miscellaneous."
[e] Not separately classified in 1913.
[f] Reported by one producer only for 1913 and included under "Miscellaneous." Statistics for zinc condensers were not collected prior to 1914.
[g] Not separately classified prior to 1918.
[h] Including adobes, aquarium ornaments, arch brick for foundations, bitumenized block, burnt-clay ballast, chemical brick pipes, rings, and tiling for acid towers, chimney pots, pipes, crocks, tops, and thimbles, chuck (broken ware), clay pigeons, crushed tile for roofing, drop bombs, porcelain filter tubes, water filters and filter stones, flue lining, garden pottery, gas logs, grave and lot markers, Indian pottery, interlocking sewer blocks, jardinieres, Holland splits, lead corroding pots, lidded pipe, light weight aggregate for concrete ships, patent rail brick to connect street railway tracks with street paving, porcelain interiors for refrigerators, porcelain shuttle eyes and thread guides, radial chimney brick and block, radial sewer brick, ruffled brick, rustic stumps, segment block, sewer brick and block, souvenirs, stone sewer trap covers, sun dails, tunnel brick, umbrella stands, wall and chimney coping, and water tables.

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BRICK AND TILE.

PRODUCTION BY STATES.

The following tables show the output and value of the building brick and other structural products of clay, and of the fire brick, paving brick, and other clay products used in engineering work, the rank of the State in these products, and the percentage of the total value of each State in 1917 and 1918. (See also fig. 97, p. 883.)

Brick and tile products in the United States in 1917.

Rank.	State.	Common brick.			Vitrified brick or block.		
		Quantity. (thousands).	Value.	Average price per thousand.	Quantity (thousands).	Value.	Average price per thousand.
20	Alabama	81,574	$557,920	$6.84	21,319	$316,914	$14.87
44	Arizona	12,964	121,974	9.41	.....	.....	.....
30	Arkansas	68,711	484,273	7.05	.....	.....	.....
10	California	169,045	1,207,765	7.14	5,839	101,909	17.45
18	Colorado	50,239	389,394	7.75	1,311	16,506	12.59
22	Connecticut and Rhode Island	142,106	1,458,386	10.26	(a)	(a)	19.06
42	Delaware	14,597	194,276	13.31	.....	.....	.....
43	District of Columbia	(a)	(a)	8.30	.....	.....	.....
40	Florida	28,457	216,989	7.63	.....	.....	.....
14	Georgia	179,598	1,200,790	6.69	(a)	(a)	12.57
41	Idaho and Nevada	15,611	151,694	9.72	.....	.....	.....
3	Illinois	738,963	5,138,822	6.95	171,067	2,533,046	14.79
6	Indiana	106,855	821,617	7.69	48,330	776,218	16.06
7	Iowa	119,984	1,045,790	8.72	5,927	83,310	14.06
13	Kansas	103,232	698,452	6.77	42,774	597,241	13.96
9	Kentucky	63,410	492,098	7.76	(a)	(b)	14.43
35	Louisiana	60,970	390,718	6.41	.....	.....	.....
34	Maine	25,457	235,530	9.25	(a)	(a)	43.00
17	Maryland	93,237	856,412	9.19	(a)	(a)	21.37
21	Massachusetts	98,644	1,031,427	10.46	.....	.....	.....
12	Michigan	236,612	1,882,042	7.95	(a)	(a)	17.76
16	Minnesota	86,606	656,247	7.58	(a)	(a)	14.00
33	Mississippi	67,936	493,022	7.26	.....	.....	.....
4	Missouri	116,887	951,324	8.14	32,770	493,114	15.05
32	Montana	35,644	397,675	11.16	(a)	(a)	24.00
27	Nebraska	98,731	822,982	8.34	(a)	(a)	26.31
36	New Hampshire	34,558	411,876	11.92	.....	.....	.....
5	New Jersey	205,794	1,843,246	8.96	.....	.....	.....
39	New Mexico	11,918	110,400	9.26	(a)	(a)	14.00
8	New York	656,508	5,068,028	7.72	16,451	293,831	17.86
23	North Carolina	172,842	1,346,211	7.79	.....	.....	.....
38	North Dakota	12,640	115,633	9.15	.....	.....	.....
2	Ohio	408,203	3,895,164	9.54	186,364	2,757,766	14.80
19	Oklahoma	121,803	800,234	6.57	13,834	189,584	13.70
37	Oregon	12,549	108,914	8.68	.....	.....	.....
1	Pennsylvania	586,632	5,704,680	9.72	75,995	1,202,216	15.82
48	Porto Rico	390	3,374	8.65	.....	.....	.....
31	South Carolina	77,115	557,500	7.23	.....	.....	.....
47	South Dakota	3,999	42,442	10.61	.....	.....	.....
25	Tennessee	120,845	907,876	7.51	(a)	(a)	15.52
11	Texas	202,285	1,444,026	7.14	(a)	(a)	12.33
29	Utah	38,923	360,114	9.25	(a)	(a)	21.27
46	Vermont	5,499	53,344	9.70	.....	.....	.....
24	Virginia	155,383	1,306,524	8.41	.....	.....	.....
26	Washington	43,487	367,906	8.46	(a)	(a)	20.40
15	West Virginia	61,519	582,185	9.46	33,044	474,772	14.37
28	Wisconsin	95,787	817,110	8.53	.....	.....	.....
45	Wyoming	9,461	103,140	10.90	.....	.....	.....
	Undistributed b	10,699	88,848	.....	51,909	831,133	16.01
		5,864,909	47,936,344	8.17	c 706,934	c 10,664,560	15.09
	Percentage of brick and tile products	.....	27.2	.....	.....	6.0	.....
	Percentage of total clay products	.....	20.6	.....	.....	4.6	.....

a Included in "Undistributed."
b Includes all products made by less than 3 producers in 1 State.
c These totals are composed of 562,234,000 vitrified brick or block sold for paving and valued at $9,076,655, and 144,700,000 vitrified brick or block sold for other purposes and valued at $1,587,905.

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Brick and tile products in the United States in 1917—Continued.

Rank.	State.	Face brick.			Fancy or ornamental brick.	Drain tile.	Sewer pipe.	Architectural terra cotta.
		Quantity (thousands).	Value.	Average price per thousand.	Value.	Value.	Value.	Value.
20	Alabama	(a)	(a)	$12.17	.....	$17,261	(a)	.....
44	Arizona	(a)	(a)	26.00	.....	.....	.....	.....
30	Arkansas	4,610	$56,409	12.24	.....	(a)	.....	.....
10	California	8,933	197,773	22.14	(a)	60,337	$794,617	$537,972
18	Colorado	13,330	174,631	13.10	(a)	105,926	(a)	(a)
22	Connecticut and Rhode Island	(a)	(a)	19.20	(a)	.....	.....	.....
42	Delaware	(a)	(a)	25.00	.....	(a)	.....	.....
43	District of Columbia	.....	.....	.....	.....	(a)	(a)	.....
40	Florida	.....	.....	.....	.....	(a)	.....	.....
14	Georgia	8,326	112,734	13.54	.....	7,152	674,188	(a)
41	Idaho and Nevada	(a)	(a)	20.17	.....	.....	.....	.....
3	Illinois	63,074	785,056	12.45	(a)	1,314,006	997,419	2,060,954
6	Indiana	74,279	880,219	11.85	.....	1,564,542	766,665	(a)
7	Iowa	18,426	282,840	15.35	(a)	4,004,989	455,561	.....
13	Kansas	37,579	388,355	10.33	(a)	76,222	(a)	(a)
9	Kentucky	1,844	21,844	11.85	.....	74,501	(a)	.....
35	Louisiana	(a)	(a)	10.38	.....	.....	.....	.....
34	Maine	.....	.....	.....	.....	.....	(a)	.....
17	Maryland	(a)	(a)	15.18	.....	1,495	.....	(a)
21	Massachusetts	(a)	(a)	11.26	.....	.....	.....	.....
12	Michigan	(a)	(a)	18.00	.....	734,042	(a)	.....
16	Minnesota	13,600	194,800	14.32	.....	579,461	(a)	.....
33	Mississippi	(a)	(a)	13.70	.....	34,843	.....	.....
4	Missouri	36,739	484,524	13.19	(a)	211,845	1,620,569	(a)
32	Montana	3,428	69,464	20.26	.....	(a)	.....	.....
27	Nebraska	2,179	48,010	22.03	.....	(a)	.....	.....
36	New Hampshire	.....	.....	.....	.....	.....	.....	.....
5	New Jersey	20,505	358,280	17.47	(a)	31,300	(a)	1,322,202
39	New Mexico	(a)	(a)	16.34	.....	(a)	.....	.....
8	New York	3,675	50,938	13.86	(a)	94,831	(a)	813,112
23	North Carolina	(a)	(a)	10.98	.....	(a)	(a)	.....
38	North Dakota	(a)	(a)	20.10	(a)	.....	.....	.....
2	Ohio	130,476	1,742,680	13.36	$12,964	1,696,763	6,897,255	.....
19	Oklahoma	5,788	65,819	11.37	.....	.....	.....	.....
37	Oregon	2,610	53,045	20.32	(a)	79,718	6,939	.....
1	Pennsylvania	199,357	2,745,031	13.77	28,979	12,595	1,970,996	873,671
48	Porto Rico	.....	.....	.....	.....	.....	.....	.....
31	South Carolina	(a)	(a)	15.57	.....	(a)	.....	.....
47	South Dakota	(a)	(a)	19.71	.....	.....	.....	.....
25	Tennessee	8,892	128,709	14.47	(a)	88,571	(a)	.....
11	Texas	24,428	396,433	16.31	.....	7,719	(a)	.....
29	Utah	9,570	147,881	15.45	.....	35,041	(a)	(a)
46	Vermont	.....	.....	.....	.....	.....	.....	.....
24	Virginia	15,809	226,890	14.35	(a)	10,440	(a)	.....
26	Washington	3,565	60,404	16.94	.....	30,755	340,621	190,468
15	West Virginia	3,524	45,325	12.86	.....	5,708	(a)	.....
28	Wisconsin	12,643	187,371	14.82	.....	102,047	.....	.....
45	Wyoming	(a)	(a)	17.93	(a)	(a)	.....	.....
	Undistributed [b]	30,431	483,908	.....	150,129	26,053	2,782,381	875,171
		757,618	10,391,368	13.72	[c]1,081,971	11,008,163	17,307,211	6,173,550
	Percentage of brick and tile products	.....	5.9	.....	[c]0.6	6.2	9.8	3.5
	Percentage of total clay products	.....	4.5	.....	[c].5	4.7	7.4	2.6

[a] Included in "Undistributed."
[b] Includes all products made by less than 3 producers in 1 State.
[c] Enameled brick, valued at $889,899, and made in California, Colorado, Illinois, Maryland, Missouri, New Jersey, Tennessee, and Utah, is included in United States total for fancy or ornamental brick.

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Brick and tile products in the United States in 1917—Continued.

Rank.	State.	Hollow building tile and fireproofing.			Tile, not drain.	Stove lining.
		Quantity (short tons).	Value.	Average price per ton.	Value.	Value.
20	Alabama	21,148	$106,700	$5.05		(a)
44	Arizona	(a)	(a)	4.00		
30	Arkansas					
10	California	39,701	258,917	6.52	$273,420	(a)
18	Colorado	9,658	68,971	7.14	(a)	
22	Connecticut and Rhode Island					(a)
42	Delaware					
43	District of Columbia	(a)	(a)	7.30		
40	Florida	(a)	(a)	12.90		
14	Georgia	(a)	(a)	5.88		
41	Idaho and Nevada	(a)	(a)	6.15		
3	Illinois	238,326	1,136,975	4.77	(a)	(a)
6	Indiana	185,719	992,132	5.34	(a)	
7	Iowa	261,488	1,542,884	5.90	(a)	(a)
13	Kansas	58,426	275,215	4.71	(a)	
9	Kentucky	10,415	49,402	4.74	343,769	
35	Louisiana	(a)	(a)	2.65		
34	Maine					
17	Maryland	(a)	(a)	5.82		(a)
21	Massachusetts	(a)	(a)	8.05	184,578	$213,322
12	Michigan	971	4,621	4.76	(a)	
16	Minnesota	45,914	233,851	5.09		(a)
33	Mississippi					
4	Missouri	41,856	294,041	7.03	(a)	(a)
32	Montana	6,985	58,477	8.37		
27	Nebraska	44,981	264,241	5.87		
36	New Hampshire					
5	New Jersey	302,648	2,167,296	7.16	1,301,960	(a)
39	New Mexico	(a)	(a)	5.33		
8	New York	24,184	140,464	5.81	72,117	108,793
23	North Carolina	(a)	(a)	6.67		(a)
38	North Dakota	8,726	49,936	5.72		
2	Ohio	906,624	3,529,003	3.88	2,642,688	60,251
19	Oklahoma	(a)	(a)	3.71		
37	Oregon	16,490	81,680	4.95		
1	Pennsylvania	189,015	903,787	4.78	495,838	112,519
48	Porto Rico					
31	South Carolina	(a)	(a)	5.15		
47	South Dakota					
25	Tennessee	2,973	18,821	6.33	(a)	
11	Texas	66,018	412,055	6.24		
29	Utah	8,408	64,159	7.63		(a)
46	Vermont					(a)
24	Virginia					
26	Washington	27,352	183,812	6.72		(a)
15	West Virginia	12,620	64,476	5.11	295,116	
28	Wisconsin	(a)	(a)	3.84		
45	Wyoming					
	Undistributed[b]	57,382	353,517		1,211,785	124,997
		2,590,028	13,255,433	5.12	[c] 6,821,221	619,882
	Percentage of brick and tile products		7.5		3.9	0.4
	Percentage of total clay products		5.7		2.9	.3

a Included in "Undistributed."
b Includes all products made by less than 3 producers in 1 State.
c Composed of the following: Roofing tile, $871,872; floor tile, $1,325,516; ceramic mosaic tile, $1,481,505 faience tile, $1,007,005; wall tile, $2,135,323.

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Brick and tile products in the United States in 1917—Continued.

Rank.	State.	Fire brick.			Miscellaneous.[a]	Total value.	Percentage of total value.
		Quantity (thousands).	Value.	Average price per thousand.	Value.		
20	Alabama	17,815	$502,936	$28.23	$10,440	$1,741,154	1.0
44	Arizona	.....	.....	.....	.....	135,474	.1
30	Arkansas	(b)	(b)	27.91	83,679	672,766	.4
10	California	22,537	626,102	27.78	62,762	4,212,974	2.4
18	Colorado	24,636	623,593	25.32	253,307	2,132,761	1.2
22	Connecticut and Rhode Island	(b)	(b)	77.03	.....	1,705,013	1.0
42	Delaware	.....	.....	.....	.....	197,310	.1
43	District of Columbia	.....	.....	.....	4,250	154,242	.1
40	Florida	.....	.....	.....	.....	224,606	.1
14	Georgia	7,132	129,514	18.16	8,590	2,414,368	1.4
41	Idaho and Nevada	(b)	(b)	23.11	.....	198,606	.1
3	Illinois	30,956	936,260	30.24	546,374	15,619,491	8.9
6	Indiana	18,749	378,317	20.18	776,678	7,828,251	4.4
7	Iowa	190	4,000	21.05	68,145	7,535,313	4.3
13	Kansas	(b)	(b)	25.71	272,917	2,695,722	1.5
9	Kentucky	115,226	3,659,437	31.76	4,300	4,883,867	2.8
35	Louisiana	(b)	(b)	46.00	25,000	440,053	.2
34	Maine	(b)	(b)	57.25	19,213	531,870	.3
17	Maryland	19,816	908,348	45.84	15,000	2,135,184	1.2
21	Massachusetts	2,165	97,207	44.90	500	1,720,988	1.0
12	Michigan	.....	.....	.....	79,996	2,846,264	1.6
16	Minnesota	(b)	(b)	41.82	66,923	2,197,664	1.2
33	Mississippi	.....	.....	.....	2,500	535,584	.3
4	Missouri	147,874	4,977,590	33.66	433,863	10,281,302	5.8
32	Montana	1,263	51,370	40.67	.....	580,230	.3
27	Nebraska	.....	.....	.....	14,311	1,160,508	.7
36	New Hampshire	.....	.....	.....	.....	411,876	.2
5	New Jersey	42,065	2,290,899	54.46	344,846	9,993,389	5.7
39	New Mexico	1,160	29,587	25.51	4,708	257,875	.1
8	New York	8,924	584,536	65.50	66,195	7,351,582	4.2
23	North Carolina	(b)	(b)	20.00	12,000	1,654,832	.9
38	North Dakota	(b)	(b)	26.01	.....	294,016	.2
2	Ohio	221,918	5,716,839	25.76	1,652,014	30,603,337	17.4
19	Oklahoma	(b)	(b)	45.33	795,883	1,857,546	1.0
37	Oregon	(b)	(b)	28.57	.....	331,546	.2
1	Pennsylvania	553,420	19,382,304	35.02	2,615,545	35,548,161	20.2
48	Porto Rico	.....	.....	.....	.....	3,374	.....
31	South Carolina	(b)	(b)	19.00	.....	654,613	.4
47	South Dakota	.....	.....	.....	.....	47,213	.....
25	Tennessee	2,154	47,455	22.03	(b)	1,569,146	.9
11	Texas	12,681	264,825	20.88	31,106	3,358,913	1.9
29	Utah	(b)	(b)	30.28	200	789,844	.4
46	Vermont	.....	.....	.....	.....	98,344	.1
24	Virginia	(b)	(b)	38.32	.....	1,625,912	.9
26	Washington	5,146	143,696	27.92	11,858	1,532,043	.9
15	West Virginia	36,505	624,278	17.10	271,363	2,364,165	1.3
28	Wisconsin	.....	.....	.....	1,873	1,114,121	.6
45	Wyoming	.....	.....	.....	.....	106,838	.1
	Undistributed[c]	11,954	522,576	.....	32,540	(d)	.....
		1,304,286	42,501,669	32.59	8,588,879	176,350,251	.....
	Percentage of brick and tile products	.....	24.1	.....	4.9	100.0	.....
	Percentage of total clay products	.....	18.3	.....	3.7	75.8	.....

[a] Including adobes, assay supplies, bitumenized blocks, burnt-clay ballast, charcoal furnaces, chemical brick and tile, chimney pipe, blocks, and tile, clay pigeons, condensers, conduits, flue crocks, flue lining, flux blocks, gas logs, gas and zinc retorts, glasshouse pots and glasshouse supplies, grave and lot markers, muffles, radial brick and block, scorifiers, segment blocks, sewer blocks, and wall coping.

[b] Included in "Undistributed."

[c] Includes all products made by less than 3 producers in 1 State.

[d] The total of "Undistributed" is distributed among the States to which it belongs, in order that they may be fully represented in the totals.

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Brick and tile products in the United States in 1918.

Rank.	State.	Common brick.			Vitrified brick or block.		
		Quantity (thousands).	Value.	Average price per thousand.	Quantity (thousands).	Value.	Average price per thousand.
16	Alabama	69,467	$714,374	$10.28	25,631	$416,463	$16.25
43	Arizona	9,700	111,381	11.48			
29	Arkansas	46,545	530,861	11.41	(a)	(a)	11.99
10	California	96,732	912,205	9.43	(a)	(a)	19.29
17	Colorado	31,872	301,220	9.45	601	9,874	16.43
24	Connecticut and Rhode Island	97,858	1,137,580	11.62	(a)	(a)	24.79
42	Delaware	11,051	161,286	14.59			
46	District of Columbia	(a)	(a)	11.07			
39	Florida	17,681	151,278	8.56			
12	Georgia	142,291	1,545,467	10.86	4,279	85,107	19.89
41	Idaho and Nevada	6,659	71,844	10.49			
3	Illinois	365,958	3,218,758	8.80	83,832	1,390,149	16.58
6	Indiana	53,964	550,461	10.20	20,229	385,625	19.06
8	Iowa	67,292	749,325	11.14	6,793	116,522	17.15
18	Kansas	56,977	511,876	8.98	21,935	364,587	16.62
7	Kentucky	33,565	379,521	11.31	(a)	(a)	20.82
35	Louisiana	36,247	408,985	11.28			
33	Maine	17,342	219,913	12.68	(a)	(a)	63.45
14	Maryland	78,525	1,063,583	13.54	(a)	(a)	22.94
25	Massachusetts	60,424	726,551	12.02			
19	Michigan	94,746	915,599	9.66	(a)	(a)	15.23
22	Minnesota	49,472	423,499	8.56			
32	Mississippi	52,309	465,176	8.89			
4	Missouri	67,614	822,212	12.16	(a)	(a)	17.44
34	Montana	24,642	326,552	13.25			
28	Nebraska	54,781	548,596	10.01	(a)	(a)	24.12
36	New Hampshire	18,958	235,219	12.41			
5	New Jersey	152,783	1,672,832	10.95			
38	New Mexico	5,397	62,430	11.57	(a)	(a)	11.99
9	New York	313,638	3,050,037	9.72	5,265	113,395	21.54
21	North Carolina	118,995	1,289,073	10.83			
40	North Dakota	6,947	72,377	10.42			
2	Ohio	230,215	2,865,568	12.45	105,166	1,809,355	17.20
23	Oklahoma	75,840	724,823	9.56	8,458	151,283	17.89
37	Oregon	8,325	94,653	11.37	(a)	(a)	47.00
1	Pennsylvania	388,948	5,066,557	13.03	57,452	1,058,689	18.43
48	Porto Rico	1,054	11,722	11.12			
31	South Carolina	52,906	582,878	11.02			
47	South Dakota	(a)	(a)	11.41			
13	Tennessee	109,857	1,302,008	11.85	(a)	(a)	18.25
11	Texas	127,607	1,311,264	10.28	(a)	(a)	12.75
30	Utah	22,348	221,745	9.92			
45	Vermont	2,104	27,609	13.12			
20	Virginia	116,678	1,474,619	12.64			
26	Washington	31,164	353,857	11.35	(a)	(a)	27.79
15	West Virginia	47,539	555,694	11.69	16,029	393,140	24.53
27	Wisconsin	69,305	687,230	9.92			
44	Wyoming	8,162	106,904	13.10			
	Undistributed [b]	4,035	45,256		47,146	851,170	
		3,556,519	38,782,458	10.90	[c] 402,816	[c] 7,145,359	17.74
	Percentage of brick and tile products.		24.8			4.6	
	Percentage of total clay products.		17.5			3.2	

[a] Included in "Undistributed."
[b] Includes all products made by less than 3 producers in 1 State.
[c] These totals are composed of 297,730,000 vitrified brick or block sold for paving, and valued at $5,656,980; and 105,086,000 vitrified brick or block sold for other purposes and valued at $1,488,379.

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Brick and tile products in the United States in 1918—Continued.

Rank.	State.	Face brick.			Fancy or ornamental brick.	Drain tile.	Sewer pipe.	Architectural terra cotta.
		Quantity (thousands).	Value.	Average price per thousand.	Value.	Value.	Value.	Value.
16	Alabama	(a)	(a)	$20.05	.....	(a)	(a)	.....
43	Arizona	(a)	(a)	20.00	.....	.....	.....	.....
29	Arkansas	2,791	$40,122	14.38	.....	(a)	.....	.....
10	California	3,954	113,616	28.73	(a)	$57,288	$610,679	$268,028
17	Colorado	12,405	225,333	18.16	$4,841	125,809	217,000	(a)
24	Connecticut and Rhode Island	(a)	(a)	25.00	.....	.....	.....	.....
42	Delaware	.....	.....	.....	.....	(a)	.....	.....
46	District of Columbia	.....	.....	.....	.....	(a)	(a)	.....
39	Florida	.....	.....	.....	.....	(a)	.....	.....
12	Georgia	5,015	86,665	17.28	(a)	9,712	826,652	(a)
41	Idaho and Nevada	(a)	(a)	18.44	.....	.....	.....	.....
3	Illinois	29,355	451,173	15.37	(a)	1,077,861	903,889	831,230
6	Indiana	37,200	582,210	15.65	(a)	1,427,237	714,605	(a)
8	Iowa	11,383	188,041	16.52	.....	2,256,200	398,848	.....
18	Kansas	21,400	292,069	13.65	(a)	75,868	(a)	(a)
7	Kentucky	(a)	(a)	18.00	.....	76,342	(a)	.....
35	Louisiana	(a)	(a)	13.01	.....	.....	.....	.....
33	Maine	(a)	(a)	12.00	.....	(a)	(a)	.....
14	Maryland	(a)	(a)	17.91	(a)	(a)	.....	(a)
25	Massachusetts	(a)	(a)	17.05	.....	.....	.....	.....
19	Michigan	(a)	(a)	24.23	.....	565,398	(a)	.....
22	Minnesota	6,444	128,888	20.00	.....	290,017	(a)	.....
32	Mississippi	(a)	(a)	20.00	.....	24,470	.....	.....
4	Missouri	9,725	151,266	15.55	7,337	154,196	1,442,660	(a)
34	Montana	2,337	48,631	20.81	.....	(a)	.....	.....
28	Nebraska	(a)	(a)	18.97	.....	(a)	.....	.....
36	New Hampshire	.....	.....	.....	.....	.....	.....	.....
5	New Jersey	6,636	147,827	22.28	(a)	25,315	(a)	387,597
38	New Mexico	(b)	(a)	19.24	.....	(a)	.....	.....
9	New York	790	13,518	17.11	.....	48,587	(a)	426,724
21	North Carolina	(a)	(a)	18.00	.....	(a)	(a)	.....
40	North Dakota	(a)	(a)	22.31	(a)	.....	.....	.....
2	Ohio	60,923	1,004,731	16.49	(a)	1,572,996	5,875,137	.....
23	Oklahoma	2,946	37,358	12.68	.....	.....	.....	.....
37	Oregon	1,754	33,765	19.25	.....	40,610	12,116	.....
1	Pennsylvania	88,023	1,526,268	17.34	9,340	5,646	1,431,496	188,691
48	Porto Rico	.....	.....	.....	.....	.....	.....	.....
31	South Carolina	(a)	(a)	19.00	.....	(a)	.....	.....
47	South Dakota	(a)	(a)	15.34	.....	.....	.....	.....
13	Tennessee	5,082	83,951	16.52	(a)	71,557	343,216	.....
11	Texas	14,891	310,330	20.84	.....	(a)	(a)	.....
30	Utah	6,839	130,911	19.14	.....	74,173	(a)	.....
45	Vermont	.....	.....	.....	.....	.....	.....	.....
20	Virginia	4,675	87,045	18.62	(a)	(a)	(a)	.....
26	Washington	2,476	60,884	24.59	.....	60,132	309,243	94,361
15	West Virginia	824	14,220	17.26	.....	9,988	.....	.....
27	Wisconsin	6,214	90,918	14.63	.....	94,006	.....	.....
44	Wyoming	(a)	(a)	25.26	.....	(a)	.....	.....
	Undistributed b	12,312	245,380	.....	51,568	52,791	2,248,132	462,062
		356,394	6,095,120	17.10	c553,858	8,196,199	15,333,673	2,658,693
	Percentage of brick and tile products	.....	3.9	.....	c.3	5.2	9.8	1.7
	Percentage of total clay products	.....	2.7	.....	c.3	3.7	6.9	1.2

a Included in "Undistributed."
b Includes all products made by less than 3 producers in 1 State.
c Enameled brick, valued at $480,772 and made in California, Illinois, Maryland, Missouri, and New Jersey, is included in United States total for fancy or ornamental brick.

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Brick and tile products in the United States in 1918—Continued.

Rank.	State.	Hollow building tile and fireproofing.			Tile, not drain.	Stove lining
		Quantity (short tons).	Value.	Average price per ton.	Value.	Value.
16	Alabama	25,818	$163,126	$6.32	.....	(a)
43	Arizona	(a)	(a)	6.00	.....	.....
29	Arkansas	.....	.....	.....	.....	.....
10	California	39,933	267,577	6.70	$255,496	(a)
17	Colorado	21,873	194,848	8.91	(a)	.....
24	Connecticut and Rhode Island	(a)	(a)	10.61	.....	(a)
42	Delaware	.....	.....	.....	.....	.....
46	District of Columbia	(a)	(a)	6.46	.....	.....
39	Florida	(a)	(a)	12.00	(a)	.....
12	Georgia	17,989	105,305	5.85	.....	.....
41	Idaho and Nevada	(a)	(a)	6.88	.....	.....
3	Illinois	172,470	961,130	5.69	(a)	(a)
6	Indiana	145,255	1,099,350	7.57	650,054	.....
8	Iowa	238,789	1,550,076	6.49	(a)	.....
18	Kansas	51,807	312,748	6.04	(a)	(a)
7	Kentucky	23,961	178,761	7.46	234,829	(a)
35	Louisiana	(a)	(a)	14.21	.....	.....
33	Maine	.....	.....	.....	.....	.....
14	Maryland	8,741	61,022	6.98	.....	(a)
25	Massachusetts	(a)	(a)	9.89	(a)	$248,071
19	Michigan	(a)	(a)	6.25	(a)	.....
22	Minnesota	62,791	369,487	5.88	.....	.....
32	Mississippi	(a)	(a)	4.05	.....	.....
4	Missouri	43,770	350,730	8.01	(a)	(a)
34	Montana	5,113	40,387	7.90	(a)	.....
28	Nebraska	37,083	210,557	5.68	.....	.....
36	New Hampshire	.....	.....	.....	.....	.....
5	New Jersey	180,127	1,573,829	8.74	872,879	(a)
38	New Mexico	(a)	(a)	6.65	.....	.....
9	New York	23,961	174,974	7.30	(a)	90,595
21	North Carolina	(a)	(a)	8.00	.....	(a)
40	North Dakota	(a)	(a)	5.93	.....	.....
2	Ohio	596,718	3,510,494	5.88	2,022,473	(a)
23	Oklahoma	(a)	(a)	4.50	.....	.....
37	Oregon	6,483	50,299	7.76	.....	.....
1	Pennsylvania	151,551	1,045,855	6.90	350,171	119,696
48	Porto Rico	.....	.....	.....	.....	.....
31	South Carolina	.....	.....	.....	.....	.....
47	South Dakota	.....	.....	.....	.....	.....
13	Tennessee	8,707	82,828	9.51	(a)	.....
11	Texas	35,403	292,863	8.27	.....	.....
30	Utah	6,111	42,377	6.93	.....	(a)
45	Vermont	.....	.....	.....	.....	(a)
20	Virginia	.....	.....	.....	.....	.....
26	Washington	15,678	112,143	7.15	.....	(a)
15	West Virginia	2,678	15,005	5.60	165,195	.....
27	Wisconsin	(a)	(a)	7.06	.....	.....
44	Wyoming	(a)	(a)	11.60	.....	.....
	Undistributed [b]	30,582	251,331	8.22	530,972	215,651
		1,953,392	13,037,102	6.67	[c] 5,082,069	673,953
	Percentage of brick and tile products	.....	8.3	.....	3.2	.4
	Percentage of total clay products	.....	5.9	.....	2.3	.3

[a] Included in "Undistributed."
[b] Includes all products made by less than 3 producers in 1 State.
[c] Composed of the following: Roofing tile, $729,981; floor tile, $1,075,474; ceramic mosaic tile, $956,459; faience tile, $724,734; wall tile, $1,595,424.

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Brick and tile products in the United States in 1918—Continued.

Rank.	State.	Fire brick.			Miscellaneous.[a]	Total value.	Percentage of total value.
		Quantity (thousands).	Value.	Average price per thousand.	Value.		
16	Alabama	16,579	$547,930	$33.05	$29,494	$2,143,780	1.4
43	Arizona					123,381	.1
29	Arkansas	(b)	(b)	35.72	51,071	679,183	.4
10	California	27,647	966,570	34.96	99,232	3,665,290	2.3
17	Colorado	23,897	731,573	30.61	192,929	2,089,889	1.3
24	Connecticut and Rhode Island	(b)	(b)	119.19		1,423,782	.9
42	Delaware					164,486	.1
46	District of Columbia				2,593	61,606	
39	Florida					181,339	.1
12	Georgia	4,720	106,559	22.58	40,867	2,944,869	1.9
41	Idaho and Nevada	(b)	(b)	35.34		173,611	.1
3	Illinois	27,837	1,040,855	37.39	646,074	10,690,042	6.8
6	Indiana	11,765	323,329	27.48	425,296	6,175,417	3.9
8	Iowa				33,206	5,313,394	3.4
18	Kansas	(b)	(b)	29.00	124,791	2,064,520	1.3
7	Kentucky	114,951	4,859,502	42.27		6,007,032	3.8
35	Louisiana	(b)	(b)	51.70	(b)	450,556	.3
33	Maine	(b)	(b)	82.97	5,831	500,725	.3
14	Maryland	21,396	1,091,242	51.00	25,000	2,378,899	1.5
25	Massachusetts	1,873	121,082	64.62		1,327,079	.9
19	Michigan	(b)	(b)	40.09	73,511	1,708,736	1.1
22	Minnesota				32,362	1,503,659	1.0
32	Mississippi				7,926	513,441	.3
4	Missouri	109,073	5,337,128	48.93	174,553	9,146,701	5.8
34	Montana	854	47,545	55.67	1,100	464,715	.3
28	Nebraska				10,000	789,612	.5
36	New Hampshire					235,219	.2
5	New Jersey	40,202	2,880,413	71.65	458,240	8,170,402	5.2
38	New Mexico	3,708	76,802	20.71	385	183,607	.1
9	New York	9,213	704,465	76.46	122,944	4,845,482	3.1
21	North Carolina	(b)	(b)	20.00	6,730	1,581,248	1.0
40	North Dakota	(b)	(b)	36.17	57	176,843	.1
2	Ohio	222,190	7,024,972	31.62	1,385,477	27,119,526	17.3
23	Oklahoma				580,718	1,496,490	1.0
37	Oregon	(b)	(b)	30.63		232,564	.2
1	Pennsylvania	530,688	24,001,066	45.23	2,220,368	37,023,783	23.6
48	Porto Rico					11,722	
31	South Carolina	(b)	(b)	25.00		600,093	.4
47	South Dakota					32,161	
13	Tennessee	(b)	(b)	29.53	261,409	2,409,476	1.5
11	Texas	8,024	207,865	25.91	48,961	2,958,328	1.9
30	Utah	(b)	(b)	36.86	4,354	610,288	.4
45	Vermont					87,609	.1
20	Virginia	(b)	(b)	32.93		1,636,873	1.1
26	Washington	4,042	151,914	37.58	14,465	1,274,708	.8
15	West Virginia	31,546	754,570	23.92	387,659	2,295,471	1.5
27	Wisconsin				1,508	874,172	.6
44	Wyoming					110,091	.1
	Undistributed[c]	12,147	672,307		16,466	(d)	
		1,222,352	51,647,639	42.25	7,455,577	156,661,700	100.0
	Percentage of brick and tile products		33.0		4.8	100.0	
	Percentage of total clay products		23.3		3.4	70.7	

[a] Including adobes, assay supplies, charcoal furnaces, chemical or acid-proof brick, block and tile, cylinders, rings, and other forms of tower packing, used in the manufacture of acids at nitrate plants and in petroleum refineries, chimney pipe, and block, clay pigeons, condensers, conduits, drop bombs, flues and flue lining, gas logs, gas and zinc retorts, glasshouse pots and glasshouse supplies, grave and lot markers, light weight aggregate for concrete ships, muffles, patent rail brick to connect street railway tracks with street paving, radial brick, block and tile, scorifiers, segment block, sewer brick and block, tunnel block, wall and chimney coping, and water tables.

[b] Included in "Undistributed."

[c] Includes all products made by less than 3 producers in 1 State.

[d] The total of "Undistributed," is distributed among the States to which it belongs, in order that they may be fully represented in the totals.

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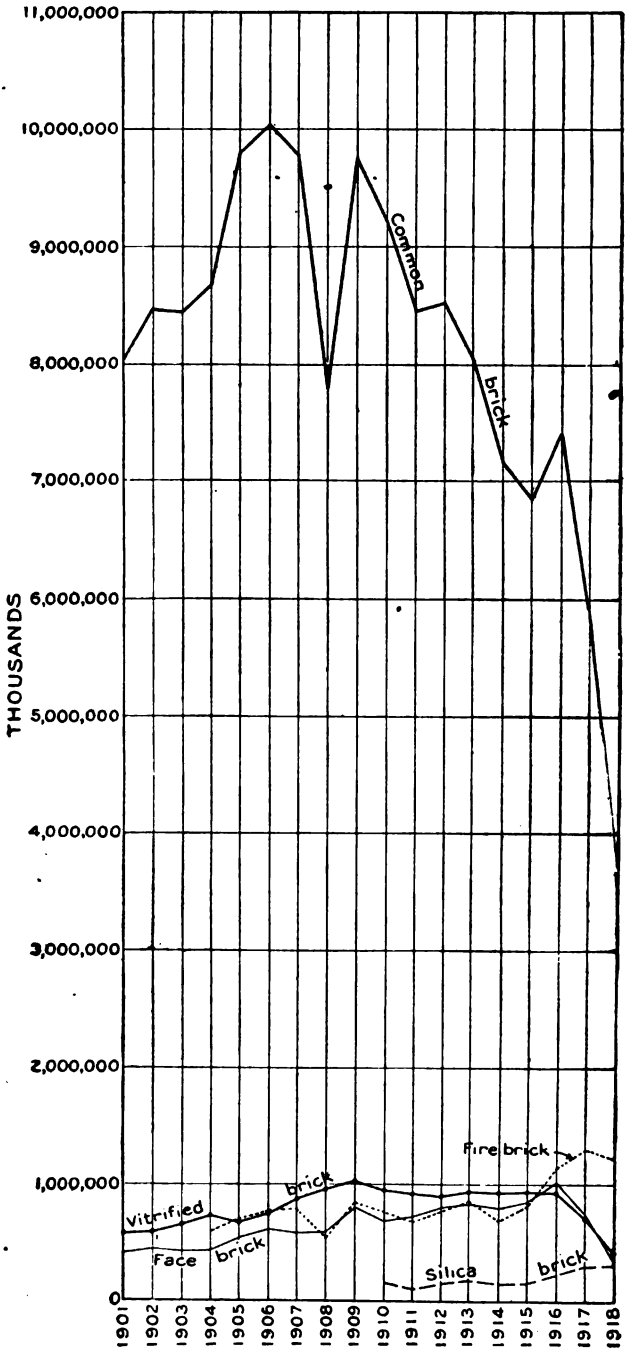

FIGURE 97.—Brick sold in the United States, 1901–1918.

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Brick and tile products, as classified herein, were reported from every State, the District of Columbia, and Porto Rico. Three States, California, Illinois, and Missouri, reported every variety of ware classified as brick and tile, and three, Kansas, New Jersey, and Pennsylvania, reported all but one.

By reason of the unusual conditions prevailing in 1918 there was a decrease of $19,688,551, or 11 per cent, in the value of brick and tile products, as compared with 1917. Pennsylvania was the leading State, as for many years Ohio was second and Illinois third. There was an increase of $1,475,622, or 4 per cent, in the value of Pennsylvania's brick and tile products. Fire brick was Pennsylvania's principal clay product, its value being 65 per cent of the value of all brick and tile products in that State; common brick was Pennsylvania's second brick and tile product, constituting 14 per cent of the total; and face brick was the third, constituting 4 per cent of the total. In Ohio there was a decrease of $3,483,811, or 11 per cent. Ohio's leading brick and tile product was fire brick, constituting 26 per cent of the total, with sewer pipe second and fireproofing third. Illinois brick and tile products decreased $4,929,449, or 32 per cent. The principal product was common brick, constituting 30 per cent of the total; vitrified brick was the second product in value, 13 per cent of the total, and draintile was third. Missouri ranked fourth, and its principal clay product was fire brick, which in 1918 constituted 58 per cent of the total; sewer pipe was second in value, and common brick was third, these two products constituting, respectively, 16 and 9 per cent of the State's total value. In New Jersey, the fifth State, the leading brick and tile product was fire brick, the value of which constituted 35 per cent of the State's total; common brick was second, 20 per cent of the total; and fireproofing was third, 19 per cent of the total. Indiana was sixth in both years. Kentucky rose from ninth in 1917 to seventh in 1918; Alabama rose from twentieth to sixteenth, Virginia from twenty-fourth to twentieth, and Tennessee from twenty-fifth to thirteenth.

Brick and tile products increased in value in 11 States—Alabama, Arkansas, Georgia, Kentucky, Louisiana, Maryland, Pennsylvania, Porto Rico, Tennessee, Virginia, and Wyoming. The increase in Kentucky, Maryland, and Pennsylvania was due principally to the increase in the value of fire brick, and in Alabama, Georgia, Tennessee, and Wyoming common brick was the principal factor in the increase.

The only clay product reported from every State, the District of Columbia, and Porto Rico is common brick. This product, the value of which constituted nearly 18 per cent of the value of all clay products and nearly 25 per cent of the brick and tile products in 1918, decreased 2,308,390,000 brick, or 39 per cent in quantity, and the value decreased $9,153,886, or 19 per cent. In 1917 there was a decrease of 1,529,293,000 brick, or 21 per cent, compared with 1916. Porto Rico was the only place to show an increase in output of common brick. Ten States showed increase in value of common brick, namely, Alabama, Arkansas, Georgia, Louisiana, Maryland, Porto Rico, South Carolina, Tennessee, Virginia, and Wyoming, and every State showed an increase in average price per thousand.

Pennsylvania was the largest producer of commmon brick in 1918, rising from third place in 1917 and displacing Illinois, which was second; New York was third, Ohio fourth, and New Jersey fifth.

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Pennsylvania's output of common brick in 1918 was 388,948,000, or 11 per cent of the total, a decrease of 197,684,000 brick, or 34 per cent. The value of common brick marketed in Pennsylvania in 1918 was $5,066,557, a decrease of $638,123, or 11 per cent. Philadelphia was the largest producing county in Pennsylvania. It reported 84,637,000 common brick, valued at $1,208,921, or $14.28 per thousand, a decrease of 55,631,000 brick, or 40 per cent, and of $120,886, or 9 per cent, in value, compared with 1917. The output of this county was 22 per cent of the State's total. The output in Illinois decreased 373,005,000 brick, or 50 per cent, and the value decreased $1,920,064, or 37 per cent. Cook was the leading county in the production of common brick. Its output in 1918 was 200,014,000 common brick valued at $1,508,623, or $7.54 per thousand, or 55 per cent of the State's output. This was a decrease of 297,221,000 brick, or 60 per cent, and of $1,817,607, or 55 per cent. In both of these States the brickmaking centers are the largest cities, and it is interesting to note that the proportionate decrease in output was larger in these cities than the proportionate decrease in the States at large, indicating that the falling off in building operations, where common brick finds its greatest use, was greater in the larger cities than in the smaller ones. In New York the output of common brick decreased 342,870,000 brick, or 52 per cent, and the value decreased $2,017,991, or 40 per cent. In this State the principal common brick-producing region is along the Hudson River. The production in that region was 211,574,000 brick or 67 per cent of the State's output. This was a decrease of 255,470,000 brick, or 55 per cent.

The average price per thousand for common brick, which ranged from $8.56 in Florida and Minnesota to $14.59 in Delaware, increased in every State. The largest increase was in Louisiana, $4.87 and the smallest in New Hampshire, 49 cents. In 6 States the increase was less than $1; in 11 it was between $1 and $2; in 16 it was between $2 and $3; in 8 it was between $3 and $4; and in 7 it was more than $4. The average price for the whole country increased $2.73.

Vitrified brick or block, the sixth brick and tile product in value in 1918, was reported from 26 States. This was a decrease of one, as Arkansas and Oregon, which reported none for 1917, marketed vitrified brick in 1918, and Minnesota, Montana, and Utah, which were producers in 1917, reported none for 1918. Ohio, as for many years was the leading State and reported 26 per cent of the total output and 25 per cent of the total value. This was a decrease in quantity of 81,198,000 brick or block, or 44 per cent, and of $948,411, or 34 per cent in value. The average price per thousand increased $2.40, compared with 1917. Stark County was the leading vitrified brick producing county, with Cuyahoga second and Muskingum third. Illinois ranked second reporting 21 per cent of the total output and 19 per cent of the total value in 1918. This was a decrease of 87,235,000 brick or block, or 51 per cent, and of $1,139,897, or 45 per cent, in value, compared with 1917. Livingston County was the leading vitrified brick producing county. Pennsylvania was third reporting 14 per cent of the output and 15 per cent of the value. The decrease in quantity in this State was 18,543,000 brick or block, or 24 per cent, and $143,527, or 12 per cent, in value. Alabama was fourth with 6 per cent and Kansas was fifth with 5 per cent of the output and value. These five States reported more than 70 per

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cent of the entire output and value. These relative ranks have been maintained for years except that Alabama rose from eighth in 1917 to fourth in 1918, and Indiana, which was fourth in 1917, was sixth in 1918 and showed a large decrease in both output and value. Five States—Alabama, Iowa, Maine, Michigan, and Tennessee— increased in output and value of vitrified brick in 1918. Of the output marketed in 1918, 297,730,000 brick or block, or 74 per cent, was sold for paving and 105,086,000, or 26 per cent, was sold for other purposes. This was a decrease of 264,504,000 brick or block, or 47 per cent, in the output sold for paving and of 39,614,000 brick or block, or 27 per cent, in the output sold for other purposes, compared with 1917. The average price per thousand for vitrified brick or block sold for paving was $19, sold for other purposes $14.16, an increase of $2.86 and $3.19, respectively. The number of vitrified brick or block marketed in 1918 was 402,816,000, a decrease of 304,118,000, or 43 per cent. The average price per thousand ranged in the more important States from $12.75 in Texas to $27.79 in Washington.

The manufacture of face brick is the most widely distributed branch of the clay-working industries, except that of common brick, and in 1918 it was reported from 42 States, the same number of States as in 1917, but Delaware reported none for 1918 and Maine reentered the list of producers. Pennsylvania, as for many years, was the leading producer, reporting 25 per cent of the output and value in 1918. This was a decrease of 111,334,000 brick, or 56 per cent, and of $1,218,763, or 44 per cent. Armstrong was the leading face-brick producing county, and reported 23,202,000 brick, valued at $414,022, or 26 per cent of the State's total, and 27 per cent of the State's value, of this kind of brick. Ohio was second, Indiana third, Illinois fourth, and Kansas fifth in output, as in 1917. In value these ranks were the same, except that Kansas was sixth in value and Texas was fifth. All showed large decreases in output and value. The first five States reported two-thirds of the marketed product in 1918. The average price per thousand ranged from $12 in Maine, where there was a small production, to $28.73 in California.

The average price for the whole country increased $3.38. Three of the smaller producing States, namely, Idaho and Nevada (taken together), Mississippi, and South Dakota increased in output and value, and Colorado and Washington increased in value. All other States decreased in output and value. There was a decrease in the output of face brick reported in 1918 of 401,224,000 brick, or 53 per per cent, compared with 1917.

Draintile was fifth among the brick and tile products in value of output in 1918, and was reported from 37 States, an increase of 1—Maine. Iowa, Ohio, Indiana, Illinois, Michigan, and Minnesota, in the order given, continue to be the leading States in the production of draintile. These six States, together, reported draintile marketed to the value of $7,189,709, or 88 per cent of the total. This was a decrease of $2,704,094, or 27 per cent. Iowa showed a decrease of $1,748,789, or 44 per cent. The other States mentioned each showed large decreases.

Sewer pipe, the third brick and tile product in value in 1918, was reported from 25 States, a decrease of 1—West Virginia. Ohio, as for many years, was the leading State and reported 38 per cent of the entire output. The value of this output decreased $1,022,118,

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or 15 per cent, compared with 1917. In 1917 it increased $1,764,445, or 34 per cent. Missouri was second, displacing Pennsylvania by a slight margin and regaining its former position. Illinois was fourth and Georgia was fifth, Georgia having risen from seventh place in 1917. The first five States reported 68 per cent of the total for 1918. All these States, except Georgia, showed considerable decrease compared with 1917. Notwithstanding the general decrease in the value of sewer pipe, 10 States, Alabama, Georgia, Kansas, Kentucky, Maine, New York, Oregon, Tennessee, Texas, and Virginia showed increase in value of sewer pipe marketed.

Architectural terra cotta was reported from 12 States, a decrease of 1—Utah. Illinois was the leading State as for many years, and reported 31 per cent of the total. The decrease in 1918 was $1,229,724, or 60 per cent, compared with 1917. New York was second, displacing New Jersey, which was third. These three States reported 62 per cent of the total for 1918. All showed large decreases from 1917. In fact, of the 12 States reporting terra cotta in 1918, only one, Georgia, showed an increase in value of output.

Hollow tile, the fourth brick and tile product in value, suffered less of a decrease than any other clay structural material. It was reported from more States than any other clay product, except common and face brick, 39 States marketing this ware in 1918, an increase of 2—Connecticut, Mississippi, and Wyoming were added to the list of hollow-tile producers in 1918, and South Carolina dropped out. Ohio was the leading State and reported 31 per cent of the output and 27 per cent of the value. The output decreased 311,906 tons, or 34 per cent, but the value of the output decreased only $18,509, or one-half of 1 per cent; the average price per ton in Ohio increased $2 or to $5.88. Iowa was second in output, displacing New Jersey, and reported 238,789 tons, a decrease of 22,699 tons, or 9 per cent. Iowa was third in value, with a slight increase—$7,192—compared with 1917. Iowa reported 12 per cent of the total output and value. New Jersey was third in output and second in value. Its output decreased 122,521 tons, or 40 per cent, and its value decreased $593,467, or 27 per cent. Illinois was fourth in output and sixth in value. Pennsylvania was fifth in both output and value, and Indiana was sixth in output and fourth in value. These six States reported 76 per cent of the output and 75 per cent of the value. Of the 36 States reporting in 1917 and 1918, 13 reported increase in output and 23 decrease; 17 States reported increase in value and 19 decrease. The average price per ton ranged from $4.05 in Mississippi to $14.21 in Louisiana. The average price for the whole country increased $1.55 per ton, or to $6.67. The output decreased 636,636 tons, or 25 per cent, compared with 1917.

Tile, not drain, includes roofing, floor, wall, ceramic mosaic, and faience tile. These products were reported from 18 States, an increase of 2—Florida and Montana. Ohio continues to be the leading State and reported 40 per cent of the output, a decrease of $620,165, or 23 per cent. New Jersey was second, and Indiana third. These three States reported 70 per cent of the total for 1918. Only three of the States that reported for 1917 and 1918, Colorado, Illinois, and Missouri, showed increase in value.

Stove lining was reported as marketed in 17 States in 1918, the same number as for 1917, but Kansas and Kentucky took the place of Iowa

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and Minnesota, which reported none for 1918. Massachusetts, as for many years, was the leading State and reported 37 per cent of the total, which was an increase of $34,749, or 16 per cent, over 1917. Pennsylvania was second and New York third, as in 1917. These three States reported 68 per cent of the total.

Fire brick, now the leading clay product in value, was reported from 33 States, a decrease of 2, as Iowa, Minnesota, and Oklahoma, which were fire-brick producers in 1917, reported none for 1918, and Michigan reentered the list of producers. The quantity of 9-inch equivalent fire brick reported (1,222,352,000) decreased 81,934,000 brick, or 6 per cent, but the value ($51,647,639) increased $9,145,970, or 22 per cent, compared with 1917. The average price per thousand increased $9.66, or to $42.25. Pennsylvania continued to be the leading State, reporting 43 per cent of total output and 46 per cent of the value. This was a decrease of 22,732,000 brick, or 4 per cent, but an increase in value of $4,618,762, or 24 per cent, compared with 1917. Ohio was second, reporting 18 per cent of the total output and 14 per cent of the total value. The output in the two years was practically the same, there being an increase of 272,000 brick. The value, however, increased $1,308,133, or 23 per cent. Kentucky was third in output and fourth in value; Missouri was fourth in output and third in value; and New Jersey was fifth in output and value. These five States reported 83 per cent of the output and 85 per cent of the total value.

TILE, NOT DRAIN.

Under the head "Tile, not drain," are embraced the varieties of higher grades of tile used almost exclusively in structural work. There are numerous subdivisions and trade names for these varieties, but, owing to the small number of producers of some of them, it has been thought best to classify them as roofing, floor, ceramic mosaic, faïence, and wall tile.

The output of these wares rises and falls with building operations. Consequently every variety decreased in value in 1918 in accord with the decrease in building operations in that year.

Wall tile was the variety of greatest value in 1918—$1,595,424. If, however, floor tile and ceramic mosaics, which are used almost exclusively as floor material, are considered together, tile used for flooring was valued at $2,031,930, or 40 per cent of the total, a decrease of $775,091, or 28 per cent.

Tile, not drain, of domestic production, sold in the United States, 1915–1918.

Variety.	1915		1916		1917		1918	
	Value.	Number of firms reporting sales.	Value.	Number of firms reporting sales.	Value.	Number of firms reporting sales.	Value.	Number of firms reporting sales.
Roofing	$891,150	23	$914,240	21	$871,872	18	$729,961	16
Floor	912,180	44	1,438,231	49	1,325,516	35	1,075,474	33
Ceramic mosaic	1,185,787	19	1,308,861	19	1,481,505	19	956,456	19
Faïence	635,073	23	814,077	24	1,007,005	24	724,734	22
Wall	1,561,865	19	2,000,055	16	2,135,323	17	1,595,424	17
	5,186,055	.....	6,475,464	.....	6,821,221	.....	5,082,069	.....

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Roofing tile, constituting 14 per cent of the total and showing a decrease in value of output of $141,891, or 16 per cent, from 1917, was reported from 10 States, California, Colorado, Florida, Iowa, Kansas, Kentucky, Missouri, Ohio, Pennsylvania, and West Virginia. These are the same States that reported for 1917, except that Florida reported roofing tile in 1918 for the first time and Illinois, which reported that material in 1917, reported none for 1918. Ohio was the leading State, reporting more than one-third of the total. California was second, and Missouri third.

Floor tile, constituting 21 per cent of the total, decreased $250,042, or 19 per cent, in value compared with 1917 and was reported from 12 States, an increase of three—Illinois, Kentucky, and Montana; the other States were California, Indiana, Massachusetts, New Jersey, New York, Ohio, Pennsylvania, Tennessee, and West Virginia. Ohio was the leading State, with sales valued at $477,679, or 44 per cent of the total, a decrease of $172,365, or 27 per cent, compared with 1917. Muskingum County was the largest producer and furnished nearly 90 per cent. New Jersey was second with wares valued at $159,862, a decrease of $121,022, or 43 per cent, and Indiana was third. These three States reported 73 per cent of the entire output of this variety of tile.

Ceramic mosaic tile was reported from nine States, an increase of three—California, New York, and West Virginia; the other States were Indiana, Kentucky, Massachusetts, New Jersey, Ohio, and Pennsylvania. There was a decrease in the value of this ware of $525,049, or 35 per cent. It constituted 19 per cent of the total in 1918. Ohio was the leading State, reporting wares valued at $361,002, or 38 per cent of the total, a decrease of $127,063, or 26 per cent, compared with 1917. New Jersey was second with an output valued at $239,828, a decrease of $134,951, or 36 per cent. These two States reported 63 per cent of the total for this variety of ware.

Faïence tile, constituting 14 per cent of the total, decreased in value $282,271, or 28 per cent. It was reported from 10 States, California, Colorado, Indiana, Kentucky, Massachusetts, Michigan, New Jersey, Ohio, Pennsylvania, and West Virginia, the same as in 1917. Ohio was the leading State and reported an output valued at $298,198, or 41 per cent of the total, a decrease of $93,130, or 24 per cent. New Jersey was second with $113,160, a decrease of $52,156, or 32 per cent.

Wall tile, the variety of greatest value, constituted 32 per cent of the total, and decreased $539,899, or 25 per cent, compared with 1917. It was reported from seven States, California, Indiana, Kentucky, Missouri, New Jersey, Ohio, and Pennsylvania. Ohio was the leading State reporting wall tile valued at $622,057, or 39 per cent of the total, a decrease of $204,853, or 25 per cent. New Jersey was second with sales valued at $360,029, a decrease of $120,952, or 25 per cent. Indiana was third. These three States reported 83 per cent of the total in 1918.

HUDSON RIVER REGION.

The Hudson River region has always held an interesting and unique place in the clay-working industries. This region, so far as the brick-making industry is concerned, is located on both sides of Hudson River and extends from New York City to Cohoes. It is

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bountifully supplied with excellent clay for making common brick and is favorably located for water transportation, in many places the plants being on the water's edge. For many years this region has been the chief source of the supply of common building brick for New York City. In recent years, however, the Raritan River region in Middlesex County, N. J., has sent a considerable proportion of its output of common brick to the New York market. Hence Middlesex, together with Bergen County, N. J., has been included in the table of production of common brick along Hudson River. The year 1918 was one of great inaction. The number of producers reporting sales was the smallest since figures were published for this region, and much of the brick sold was from stock on hand, so that even fewer plants were operating than is indicated by the number of firms reporting. The lack of demand for brick in Greater New York was the principal cause of the falling off in this region. The scarcity of labor was also sharply felt, and it would have been difficult to supply anything like a normal demand for brick had it existed. The prices of common brick in New York were the highest recorded. Early in the spring wholesale prices ranged from $9.50 to $10 a thousand and they rose gradually until in December brick was sold for $15 a thousand at the dock.

Every county in this region except Middlesex County, N. J., decreased in output and value. The increase in output in this county was undoubtedly due to the large amount of structural work done by the Government and in the erection of munitions factories in New Jersey.

The output of brick in this region was the smallest recorded by the Geological Survey. The output was only about one-third as much as it was in 1912, when Middlesex County was first included, and the output of the New York-Bergen County portion of the region was less than one-fifth of that of 1909, the year of maximum production.

Common brick produced and sold in the Hudson River district, 1909–1918.

Year.	Number of firms reporting sales.	Quantity (thousands).	Value.	Average price per thousand.
1909	127	1,313,760	$6,438,642	$4.90
1910	135	1,142,284	5,544,600	4.85
1911	125	926,072	4,717,633	5.09
1912[a]	136	1,233,187	7,133,177	5.78
1913[a]	132	1,025,308	5,636,061	5.50
1914[a]	129	888,266	4,350,832	4.90
1915[a]	120	960,527	5,009,065	5.21
1916[a]	113	893,552	5,915,254	6.62
1917[a]	99	584,184	4,427,934	7.58
1918[a]	78	314,196	3,078,805	9.80

[a] Includes Raritan district, Middlesex County, N. J.

The number of brick marketed in this region in 1918 decreased 269,988,000 or 46 per cent, compared with 1917. The value of the output also decreased $1,349,129, or 30 per cent. The average price per thousand, $9.80, increased $2.22 and was the highest yet recorded. It was double the average price in 1914.

In the New York and Bergen County, N. J., portion of the region the output was 230,089,000 brick, a decrease of 275,446,000 brick,

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valued at $2,151,008, a decrease of $1,568,422. The number of operators (72) in this portion of the region reporting sales in 1918 decreased 21 as compared with 1917.

Common brick marketed in the Hudson River district (from Cohoes to New York City) and in the Raritan district, N. J., in 1917 and 1918.

County.	1917				1918			
		Common brick.				Common brick.		
	Number of firms reporting sales.	Quantity (thousands).	Value.	Average price per thousand.	Number of firms reporting sales.	Quantity (thousands).	Value.	Average price per thousand.
Albany	12	43,763	$323,298	$7.39	11	23,989	$258,225	$10.76
Columbia	a 7	a 39,629	a 314,453	7.93	a 9	23,233	215,774	9.29
Dutchess	11	56,740	411,681	7.26	11	28,376	256,918	9.05
Greene	5	23,861	138,197	5.79	5	9,875	93,405	9.46
Orange	5	61,083	441,790	7.23	3	14,775	123,177	8.34
Rensselaer	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Rockland	19	89,227	668,197	7.49	13	29,994	267,972	8.93
Ulster	20	142,768	1,040,535	7.29	14	81,332	735,140	9.04
Westchester	5	9,973	85,422	8.57	(a)	(a)	(a)	(a)
Total for New York portion of the district	84	467,044	3,423,573	7.33	66	211,574	1,950,611	9.22
Bergen County, N. J	9	38,491	295,857	7.69	6	18,515	200,397	10.82
Raritan district (Middlesex County), N. J	6	78,649	708,504	9.01	6	84,107	927,797	11.03
Grand total	99	584,184	4,427,934	7.58	78	314,196	3,078,805	9.80

a In 1917 Rensselaer County and in 1918 Rensselaer and Westchester counties are included under Columbia.

The New York portion of the region, by reason of its greater number of operators, has always been the larger producer. For 1918 it reported 67 per cent of output and 63 per cent of the value of the entire region. The quantity of brick sold in this portion of the region in 1918 decreased 255,470,000 brick, or 55 per cent, and the value decreased $1,472,962, or 43 per cent, compared with 1917.

Of the counties included in the New York portion of the region, Ulster, as for many years, was first in output and value, its 14 operators reporting 38 per cent of the output and value in 1918. There was a decrease of 61,436,000 brick, or 43 per cent, and of $305,395, or 29 per cent, in value in this county, compared with 1917. The average price per thousand in Ulster County increased $1.75. Rockland County was second, as for many years, except in 1915, when Dutchess County was second. Rockland's output decreased 59,233,000 brick, or 66 per cent, and its value decreased $400,225, or 60 per cent. Dutchess was third in output, displacing Orange County, and fourth in value, with a decrease of 28,364,000 brick, or 50 per cent, and of $154,763, or 38 per cent, in value. Every one of the other six counties showed decrease in both output and value, compared with 1917. Every county showed an increase in average price per thousand compared with 1917. The largest increase was in Greene—$3.67; the smallest was in Orange—$1.11.

The output of the New Jersey portion of this region was slightly less than half that of the New York portion, or 102,622,000 brick.

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The value of this output, $1,128,194, was slightly greater than half of that of the New York portion, owing to the higher prices received for the New Jersey brick—$10.99 a thousand. As a whole, the New Jersey portion of the region decreased in output 14,518,000 brick, or 12 per cent, but increased $123,833, or 12 per cent, in value, compared with 1917. Bergen County showed a decrease of 19,976,000 brick, or 52 per cent, and of $95,460, or 32 per cent, in value. Middlesex County was the only one in the region to show increase in output or value. The increase there was 5,458,000 brick, or 7 per cent, and $219,293, or 31 per cent, in value, compared with 1917. This increase was no doubt due to the large consumption of brick in Government work in this vicinity and in other work incident to the war.

POTTERY.

GENERAL STATEMENT.

The pottery industry of the United States in 1918 experienced another unusual year. The comparatively small imports for several years—though they increased slightly in value in 1918 over 1917—caused an increased demand for domestic ware. Even before the United States entered the war it was difficult to supply the market on account of congestion of transportation and shortage of labor, fuel, cars, and materials. As all these handicaps were greater in 1918 and were supplemented by others, the large demand by the Government for crockery for the Army and the Navy made the task of the potters still more difficult. In spite of all obstacles, however, the potters bent their efforts to the great work of helping to win the war and willingly complied with the regulations regardless of their personal sacrifices. Their burdens were not light, were frequently irksome, and were sometimes irritating, but the necessity of the Government regulations and the confusion of the hastily organized war-service bureaus were recognized as unavoidable. With the attainment of the great end, however, the sacrifices of the potters of the country were regarded as having been more than compensated, and the return of normal times should make the future of the American potter bright.

Although the value of the output was the largest yet recorded, the volume was not correspondingly large, owing to the universal increase of cost of production and the consequent high prices. In fact, the producing capacity of the potteries, which was increased but little in 1918, was reached in few if any works, the output being only from 65 to 75 per cent of their full capacity. The principal causes of the failure to reach the capacity of production were the shortage of labor due to war conditions and the indifference of some of the laborers, but scarcity of materials and fuel was a contributing factor. The high wages received, instead of acting as a stimulus, actually prevented some of the men from working full time. No extensive replacement of men by women workers, such as occurred in England and France, took place in the American potteries, though this would probably have been resorted to had the war continued much longer.

Continued efforts were made during 1918 promptly to replace men called to war, to reduce the cost of manufacture, and to increase output by introducing labor-saving machinery, such as improved stove

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rooms, automatic spreading and batting-out machines, coal unloaders, and tunnel kilns, all of which made 1918 a notable year in the improvement of the equipment of the potteries of the United States. These improvements have been chiefly in the mechanical department, but efforts to improve the body, texture, decoration, and design of the ware have not been lacking.

White House dining service.—A notable event in the pottery industry in 1918 was that of placing in the White House an American-made state dining service. This service and the circumstances of its creation are described as follows:[1]

This state dining set is sure to awaken great interest throughout the country, as it is the first White House china designed by an American artist, made [chiefly] from American clays at an American pottery, burned at American kilns, and decorated by American workmen. From the largest dish to the very tiniest, every piece of this new china, which has just been delivered at the White House, is American made. And it can be added that every piece is a work of art of which any government might be proud. The china was made at Trenton, N. J. [by Lenox, Inc.]

Few realize the work involved in securing a state dining set for the White House. Months of time were consumed in the preparation of the designs for the present service. * * * The President and Mrs. Wilson desired to have the new china equal anything that could be produced in the European potteries, primarily because it was to be the first American-made state dining set and for that reason must be above criticism. They wanted it also to be exceedingly simple, and, in these war times, the decorations must have a patriotic motif.

Under these circumstances it can be imagined easily that the manufacturer and the chief artist of the firm were fully alert in filling the commission which the firm was so delighted to receive. Design after design was worked out, only to go into the wastebasket. One morning the artist came smiling into the office.

"I believe I have it," he exclaimed as he produced a paper. "Here is a design so simple and so unostentatious it can not but suit the most æsthetic taste and yet so rich in tone it commensurates with the dignity of the home of our Chief Executive. The motif is supremely patriotic—the Stars and Stripes and the seal of the United States."

The design was approved by both the President and Mrs. Wilson, who had followed the development of the designs with keen zest. They were especially delighted with the patriotic motif. There was but one change and that came from a suggestion made by the President himself. As the china was for the President's house, he thought it more appropriate that the dishes should bear the President's seal rather than the coat-of-arms of the United States, a suggestion which was accepted.

The new state dining set is a dream of beauty in chinaware, and there can be no criticism of its texture. In round numbers the service will comprise 1,700 pieces, and each piece is in two tints, a deep ivory-colored border and the cream-white china of the center of the dish. There will be no color in any of the decorations save on the service plates. The decorations are in rolled gold. Each flat piece is edged with a narrow border of the Stars and Stripes, a group of the stars alternating with a group of an exquisite conception of the President's seal.

The tea cups and the dainty after-dinner coffee cups bear golden handles and are decorated with the same design as the plates. The flaring ramekins, the double-handled bouillon cups, the breakfast-food dishes, and the little bowls to hold the relish for the oyster cocktail in the oyster plates bear the same decorations.

The large chop plates, which will be used also as cake servers, have a narrow rim of the ivory tint on which the design is painted, while the body of the plate is the cream-white fabric. The service plate is the most beautiful plate of its kind which has ever graced the White House. The border is of an indescribable deep blue, darker than the Wedgewood and yet more brilliant. It is bordered in gold in an etching of the Adam period, including an Adam

[1] First American-made china for the White House: Sunday Star, Washington, D. C., Oct. 20, 1918.

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urn and scroll. The inner border bears the Stars and Stripes. The handsome seal is in the center of the plate and attracts the eye at the first glance. The plate measures 11 inches instead of the usual 10½, and thus enables the beauty of the decoration to be seen while it carries a soup or an entrée plate.

The fabric of the china—that is, the china itself—is of marvelous strength and fiber, and it is built to bear long usage. Not only so, but the great beauty of the entire service makes it a distinct addition in the field of ceramic art. The patriotic motif has been named "the President Wilson design."

Restrictions on production.—The only pottery products whose manufacture was restricted by reductions in the use of fuel by the Fuel Administration were sanitary ware and stoneware, except chemical stoneware. The allotments of fuel for sanitary ware and stoneware, except chemical stoneware, were, respectively, 50 per cent and 85 per cent, based on the average quantity of fuel used annually in the three years 1915 to 1917, inclusive. In spite of this restriction in fuel the value of ordinary stoneware made increased $588,339, or 15 per cent, though the quantity produced was probably less than that in 1917, notwithstanding an increase in the output of stoneware crocks and jars, which were used extensively in the preservation of food. The value of sanitary ware decreased $1,395,079, or 11 per cent, a decrease due to the reduction in general building operations, in which sanitary ware finds its chief use.

Potters' War Service Committee.—At the suggestion of the Chamber of Commerce of the United States representatives of the potters met at Washington in July, 1918, and organized a war service committee consisting of C. C. Ashbaugh (secretary), Ambrose G. Dale, William Scammell, Charles L. Sebring, J. E. Torbert, W. E. Wells (chairman), and H. E. Wintringer. This committee was frequently called to Washington for consultation with the various war boards. At one of these conferences the conservation division of the War Industries Board suggested that the manufacture of many articles not of first importance be discontinued during the war. In response to this suggestion the makers of different kinds of ware prepared lists of articles to be continued and submitted them for approval. The spirit of cooperation of the potters in this matter is best shown by the number of items eliminated. One company cut its list from 1,616 items to 116; another from 549 to 131; and another from 505 to 230.[1] On September 18 a conservation order was issued in the form of a schedule for manufacturers of vitrified china and semiporcelain ware which limited the articles to be manufactured during the war. It also provided that no new molds should be made for articles not on the permissible list, that no new decalcomania patterns or copperplate engravings be added, and that no new products be placed on the market even where the decalcomania patterns or copperplate engravings had already been made. Special designs already prepared by any pottery were not to be duplicated by any other pottery during the war. In the manufacture of vitrified china each manufacturer was restricted to not more than two basic hotel shapes to be known as "rolled edge and thick" or "rolled edge and quarter thick," and each manufacturer was restricted to one basic shape of dinner ware for family use. The order specified the kinds and sizes of articles to be made. For semiporcelain ware a similar schedule was included. The exemption of articles for the Govern-

[1] Crockery and Glass Jour., vol. 89, No. 2, Jan. 9, 1919, p. 15.

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ment was specifically provided for. On October 30 a revised schedule was promulgated in which a few more articles were permitted, principally additional sizes of those embraced in the original order. An order was issued on October 16 by the priorities division of the War Industries Board restricting the manufacture of pottery to 50 per cent of the output of 1917. This order was subsequently modified to three glost firings a month. These orders were issued late in the year and were canceled soon after the signing of the armistice, so that they had little effect on the industry. All restrictions were removed on December 1.

Importation of clay.—The subject of the importation of clay was closely studied by the United States Shipping Board and representatives of the kaolin miners and users were called before it to show cause why the importation of English china clays should not be restricted. At this meeting the matter was fully discussed but no order of curtailment was issued. The potters agreed, however, to cooperate with the Bureau of Standards in a series of experiments with a view to working up an all-American body. Accordingly a large number of combinations of such bodies was prepared by A. V. Bleininger, of that bureau. The raw materials for these experimental bodies were assembled and combined at East Liverpool, Ohio. The clay made into these body mixtures was distributed among the East Liverpool potteries to be made into sample pieces and fired in bisque, and these samples were afterward assembled at one plant to be fired in the glost. The results of these experiments are not yet available.

PRODUCTION.

The value of all domestic pottery marketed in 1918 was $65,222,951, an increase of $9,060,429, or 16 per cent, over the value in 1917. The increase in 1917 over 1916 was $7,945,280, or 16 per cent. The value in 1918 was the greatest recorded by the pottery industry in the United States. It was $27,230,576, or nearly 72 per cent, greater than that of 1913, more than twice as great as that of any year prior to 1910, and more than six times as great as in 1897. Pottery imports also increased very slightly, and the ratio of production to consumption, 93 per cent, was the highest recorded.

Every variety of ware as classified in this report, except red earthenware and sanitary ware, increased in value as compared with 1917, and all except these two attained their maximum values. White ware, which includes the commoner grades of household wares, showed the largest increase, $4,385,457, or 21 per cent; porcelain electrical supplies, the only pottery product used directly in military and naval field operations, increased $3,054,384, or 32 per cent; and china, the pottery of highest grade, increased $1,501,443, or 31 per cent. The value of china in 1918 was four times as great as it was in 1908, a fact which, even allowing for inflated values, augurs well for the future of the pottery industry. Red earthenware decreased in value $158,324, or 15 per cent, and sanitary ware decreased in value $1,395,079, or 11 per cent. One of the causes assigned for the decrease in the red earthenware was the curtailment by the Fuel Administration of fuel to florists, who are large users of flowerpots.

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The value of white ware and china, which comprise the general household wares and constitute nearly half of the value of all pottery products, was $31,613,275 in 1918, an increase of $5,886,900, or 23 per cent, over 1917. If to this sum is added the value of sanitary ware and porcelain electrical supplies, the total value in 1918 of these high-grade wares was $55,360,383, or $7,546,205 more than in 1917, and constituted 85 per cent of the value of all pottery products in 1918.

Chemical pottery—that is, chemical stoneware and chemical porcelain—which was so necessary to the manufacture of munitions of war, naturally increased greatly in both quantity and value. The increase in 1918 was $670,278, or 61 per cent. Chemical stoneware, valued at $1,547,779, increased in value $615,866, or 66 per cent. Chemical porcelain, which is a comparatively new product for the United States, was valued at $221,931, an increase of $54,412, or nearly 33 per cent.

Value of pottery products in the United States, 1909–1918.

Year.	Number of firms reporting sales.	Red earthenware.	Stoneware and yellow and Rockingham ware.	Chemical stoneware and porcelain.	White ware, including C. C. ware, etc.
1909	466	$805,906	$3,993,859	(a)	$13,728,316
1910	463	854,196	3,796,688	(a)	14,780,980
1911	449	893,678	4,120,608	(a)	14,366,251
1912	434	958,270	3,919,778	(a)	14,829,431
1913	426	1,000,529	3,683,567	(a)	15,066,811
1914	412	1,059,904	3,349,301	(a)	14,968,079
1915	416	1,072,061	3,575,603	(a)	15,324,242
1916	393	1,156,351	3,696,288	$1,054,061	18,191,390
1917	394	1,065,185	2,865,825	1,099,432	20,920,469
1918	384	906,861	4,454,164	1,769,710	25,305,926

Year.	China, bone china, delft, and belleek ware.	Sanitary ware.	Porcelain electrical supplies.	Miscellaneous.	Total.
1909	b$1,766,766	$5,989,295	$3,047,499	b$1,717,800	$31,049,441
1910	1,962,126	6,758,996	3,794,153	1,837,539	33,784,678
1911	2,057,985	7,031,458	4,232,101	1,816,479	34,518,560
1912	2,177,305	7,902,255	4,927,316	1,789,809	36,504,164
1913	2,424,060	8,214,838	5,737,741	1,864,829	37,992,375
1914	2,384,686	7,874,269	4,130,270	1,631,652	35,398,161
1915	2,330,156	7,993,216	4,671,202	2,358,908	37,325,388
1916	3,478,372	11,111,417	7,034,420	2,494,943	48,217,242
1917	4,805,906	12,636,217	9,451,586	2,317,902	56,162,522
1918	6,307,349	11,241,138	12,505,970	2,731,833	65,222,951

a Not separately classified prior to 1916.
b China, bone china, delft, and belleek ware for Ohio is included in miscellaneous.

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Value of pottery products in 1917.

Rank.	State.	Number of firms reporting sales.	Red earthenware.	Stoneware and yellow and Rockingham ware.	Chemical stoneware and porcelain.	White ware, including C. C. ware, white granite, semi-porcelain ware, and semi-vitreous porcelain ware.	China, bone china, delft, and belleek ware.
17	Alabama	11	$6,060	$12,671	.....	.....	.....
	Arkansas	.....	.....	(a)	.....	.....	.....
9	California	12	27,110	65,581	.....	.....	.....
13	Colorado	5	(a)	(a)	(a)	.....	.....
	Connecticut	.....	(a)	.....	.....	.....	.....
26	District of Columbia	.....	6,000	.....	.....	.....	.....
28	Florida	.....	.....	.....	.....	.....	.....
19	Georgia	14	5,693	6,610	.....	.....	.....
7	Illinois	18	51,787	796,194	.....	(a)	.....
6	Indiana	9	(a)	58,387	(a)	(a)	.....
27	Iowa	3	(a)	.....	.....	.....	.....
14	Kentucky	6	49,669	104,100	.....	.....	.....
23	Louisiana	.....	.....	.....	.....	.....	.....
	Maine	.....	.....	(a)	.....	.....	.....
11	Maryland	6	(a)	.....	.....	(a)	.....
12	Massachusetts	10	(a)	.....	(a)	(a)	.....
8	Michigan	8	(a)	.....	(a)	(a)	.....
	Minnesota	.....	(a)	(a)	.....	.....	.....
18	Mississippi	9	2,200	15,771	.....	.....	.....
20	Missouri	3	(a)	(a)	.....	.....	.....
30	Montana	.....	500	.....	.....	.....	.....
	Nebraska	.....	(a)	.....	.....	.....	.....
	New Hampshire	.....	.....	.....	.....	.....	.....
2	New Jersey	55	36,045	(a)	$472,681	$1,040,697	$1,632,622
4	New York	18	(a)	.....	(a)	(a)	1,574,962
24	North Carolina	16	1,269	5,756	.....	.....	.....
1	Ohio	101	280,874	1,761,468	429,449	13,222,826	(a)
	Oregon	.....	(a)	(a)	.....	.....	.....
5	Pennsylvania	20	238,456	231,431	(a)	(a)	840,043
	Porto Rico	.....	(a)	.....	.....	.....	.....
21	South Carolina	6	6,142	2,046	.....	.....	.....
10	Tennessee	8	(a)	53,750	.....	(a)	.....
15	Texas	16	9,981	82,912	.....	.....	.....
25	Utah	.....	(a)	.....	.....	.....	.....
16	Virginia	3	.....	.....	.....	.....	.....
29	Washington	.....	996	.....	.....	.....	.....
3	West Virginia	16	.....	.....	.....	4,421,017	(a)
22	Wisconsin	3	8,000	.....	.....	.....	.....
	Undistributed [b]	18	334,403	669,148	197,302	2,235,929	758,279
		394	1,065,185	3,865,825	[c]1,099,432	20,920,469	4,805,906
	Percentage of pottery products	.....	1.9	6.9	2.0	37.2	8.6
	Percentage of total clay products	.....	.4	1.7	.5	9.0	2.1
	Number of firms reporting each variety	.....	121	113	19	64	18

a Included in "Undistributed."
b Includes all products made by less than 3 producers in 1 State.
c Of this total $167,519 represents the value of chemical porcelain manufactured in Colorado, Massachusetts, Michigan, and Ohio. The remainder is chemical stoneware.

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Value of pottery products in 1917—Continued.

Rank.	State.	Sanitary ware.	Porcelain electrical supplies.	Miscellaneous.[a]	Total.	Percentage of total.
17	Alabama				$18,731	
	Arkansas			(b)	(b)	
9	California	$518,084		$2,376	613,151	1.1
13	Colorado			17,910	158,093	.3
	Connecticut		(b)		(b)	
26	District of Columbia				6,000	
28	Florida			4,800	4,800	
19	Georgia				12,303	
7	Illinois	(b)	(b)	36,421	1,571,262	2.8
6	Indiana	1,297,343	(b)		1,890,501	3.4
27	Iowa			(b)	4,900	
14	Kentucky				153,769	.3
23	Louisiana			7,888	7,888	
	Maine				(b)	
11	Maryland	(b)	(b)	6,821	332,954	.6
12	Massachusetts			43,266	250,992	.4
8	Michigan	(b)	(b)	13,722	1,187,981	2.1
	Minnesota				(b)	
18	Mississippi			30	18,001	
20	Missouri				10,675	
30	Montana				500	
	Nebraska				(b)	
	New Hampshire			(b)	(b)	
2	New Jersey	7,202,671	$1,893,382	250,195	12,535,843	22.3
4	New York	(b)	2,018,363	80,614	4,076,817	7.2
24	North Carolina			(b)	7,475	
1	Ohio	1,004,726	3,096,162	1,504,734	21,353,706	38.0
	Oregon			(b)	(b)	
5	Pennsylvania	(b)	(b)	25,869	3,194,944	5.7
	Porto Rico				(b)	
21	South Carolina				8,188	
10	Tennessee			(b)	400,080	.7
15	Texas				92,893	.2
25	Utah			(b)	7,333	
16	Virginia	(b)		(b)	32,130	.1
29	Washington				996	
3	West Virginia	1,342,970	(b)	115,660	7,243,900	12.9
22	Wisconsin				8,000	
	Undistributed[c]	1,270,423	2,443,679	207,596	957,716	1.7
		12,636,217	9,451,586	2,317,902	56,162,522	
	Percentage of pottery products	22.5	16.8	4.1	100.0	
	Percentage of total clay products	5.4	4.1	1.0	24.2	
	Number of firms reporting each variety	47	44	79		

[a] Including aquarium ornaments, art pottery, bisque doll heads, chimney tubes, craequle porcelain, filter stones, gas and electric lighting and heating appliances, Guernsey and Oxford ware, Niloak, Omar Khayyam, Pewabic, Rhead and Rookwood pottery, pins, stilts, and spurs for potters' use, porcelain door knobs and filter tubes, porcelain hardware trimmings and supplies, porcelain guides for use on textile machinery, saggers, shooting gallery pipes, shuttle eyes and thread guides, stems for laboratories and supply houses, tobacco pipes, toy marbles, turpentine cups, and vases.

[b] Included in "Undistributed."

[c] Includes all products made by less than 3 producers in 1 State.

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Value of pottery products in 1918.

Rank.	State.	Number of firms reporting sales.	Red earthenware.	Stoneware and yellow and Rockingham ware.	Chemical stoneware and porcelain.	Whiteware, including C. C. ware, white granite, semiporcelain ware, and semivitreous porcelain ware.	China, bone china, delft, and belleek ware.
18	Alabama	9	$4,023	$11,301	.....	.....	.....
24	Arizona	(a)	.....	.....	.....	.....	.....
	Arkansas	.....	.....	(b)	.....	.....	.....
9	California	a 15	48,912	112,015	.....	$23,105	.....
12	Colorado	5	(b)	(b)	(b)	.....	.....
	Connecticut	.....	(b)	.....	.....	.....	.....
	District of Columbia	.....	5,000	.....	.....	.....	.....
	Florida	.....	.....	.....	.....	.....	.....
17	Georgia	16	5,312	14,525	.....	.....	.....
8	Illinois	16	42,853	930,176	.....	(b)	.....
7	Indiana	9	(b)	64,126	.....	(b)	.....
	Iowa	.....	(b)	.....	(b)	.....	.....
14	Kentucky	5	20,784	144,738	.....	.....	.....
	Louisiana	.....	.....	.....	.....	.....	.....
11	Maryland	5	(b)	.....	.....	(b)	.....
13	Massachusetts	10	(b)	.....	(b)	(b)	.....
6	Michigan	8	(b)	.....	.....	(b)	.....
	Minnesota	.....	(b)	(b)	.....	.....	.....
19	Mississippi	7	3,926	11,114	.....	.....	.....
21	Missouri	3	(b)	(b)	.....	.....	.....
	Nebraska	.....	(b)	.....	.....	.....	.....
	New Hampshire	.....	.....	.....	.....	(b)	.....
2	New Jersey	55	31,497	(b)	$745,741	1,239,069	$1,563,181
20	New Mexico	(a)	.....	.....	.....	.....	.....
4	New York	18	(b)	.....	(b)	(b)	1,964,688
22	North Carolina	13	1,181	6,529	.....	.....	.....
1	Ohio	101	325,721	2,060,157	714,456	15,779,620	708,020
	Oregon	.....	(b)	(b)	.....	.....	.....
5	Pennsylvania	21	179,274	277,190	(b)	1,024,174	1,141,325
	Porto Rico	.....	(b)	.....	.....	.....	.....
23	South Carolina	4	3,763	(b)	.....	.....	.....
10	Tennessee	6	.....	1,817	(b)	(b)	.....
15	Texas	14	6,989	61,242	.....	.....	.....
	Utah	.....	(b)	.....	.....	.....	.....
16	Virginia	3	(b)	.....	.....	.....	.....
	Washington	.....	(b)	.....	.....	.....	.....
3	West Virginia	16	.....	.....	.....	5,480,581	(b)
	Wisconsin	.....	(b)	.....	.....	.....	.....
	Undistributed c	25	227,626	750,234	309,513	1,759,377	930,135
		a 384	906,861	4,454,164	d 1,769,710	25,305,926	6,307,349
	Percentage of pottery products	.....	1.4	6.8	2.7	38.8	9.7
	Percentage of total clay products	.....	.4	2.0	.8	11.4	2.9
	Number of firms reporting each variety	.....	102	106	18	64	19

a Under miscellaneous is included Indian pottery, valued at $12,357 manufactured on reservations and distributed by States as follows: Arizona $1,181, California $250, and New Mexico $10,926. This represents the work of several hundred Indians, but as its manufacture is largely a pastime, the number of producers is not definitely known.

b Included in "Undistributed."

c Includes all products made by less than 3 producers in 1 State.

d Of this total $221,931 represents the value of chemical porcelain manufactured in Colorado and Ohio. The remainder is chemical stoneware.

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Value of pottery products in 1918—Continued.

Rank.	State.	Sanitary ware.	Porcelain electrical supplies.	Miscellaneous.[a]	Total.	Percentage of total.
18	Alabama				$15,324	
24	Arizona			[b] $1,181	1,181	
	Arkansas			(c)	(c)	
9	California	(c)	(c)	[b] 3,898	663,930	1.0
12	Colorado			9,468	209,559	.3
	Connecticut		(c)		(c)	
	District of Columbia				5,000	
	Florida			(c)	(c)	
17	Georgia				19,837	
8	Illinois	(c)	(c)	46,099	1,769,735	2.7
7	Indiana	$1,124,550	(c)	4,600	1,775,509	2.7
	Iowa			(c)	(c)	
14	Kentucky				165,522	.3
	Louisiana			7,889	7,889	
11	Maryland	(c)	(c)	10,500	342,416	.5
13	Massachusetts			35,346	166,686	.3
6	Michigan	(c)	(c)	88,842	1,976,436	3.0
	Minnesota			(c)	(c)	
19	Mississippi				15,040	
21	Missouri				8,387	
	Nebraska				(c)	
	New Hampshire			(c)	(c)	
2	New Jersey	6,151,752	$2,437,133	379,280	12,570,842	19.3
20	New Mexico			[b] 10,926	10,926	
4	New York	(c)	3,595,478	135,276	6,047,472	9.3
22	North Carolina			(c)	8,260	
1	Ohio	1,044,320	3,386,555	1,760,805	25,779,654	39.5
	Oregon				(c)	
5	Pennsylvania	(c)	(c)	40,385	3,443,321	5.3
	Porto Rico				(c)	
23	South Carolina				5,675	
10	Tennessee			(c)	382,391	.6
15	Texas				68,231	.1
	Utah				(c)	
16	Virginia	(c)		(c)	29,981	.1
	Washington				(c)	
3	West Virginia	1,312,004	816,683	153,803	8,693,206	13.3
	Wisconsin				(c)	
	Undistributed[d]	1,608,512	2,270,121	43,535	1,040,541	1.6
		11,241,138	12,505,970	[b] 2,731,833	65,222,951	
	Percentage of pottery products	17.2	19.2	4.2	100.00	
	Percentage of total clay products	5.1	5.6	1.2	29.4	
	Number of firms reporting each variety	46	50	107		

[a] Including aquarium ornaments, art pottery, chimney tubes, cracqule porcelain, filter stones, gas and electric lighting and heating appliances, garden furniture, Guernsey and Oxford ware, Indian, Nilcak, Omar Khayyam, Pewabic and Rookwood pottery, pins, stilts and spurs for potters' use, porcelain door knobs and filter tubes, porcelain hardware supplies, porcelain guides for use on textile machinery, saggers, shuttle eyes and thread guides, tobacco pipes, toy marbles, turpentine cups, umbrella stands, and vases.

[b] Under miscellaneous is included Indian pottery valued at $12,357 manufactured on reservations and distributed by States as follows: Arizona $1,181, California $250, and New Mexico $10,926. This represents the work of several hundred Indians, but as its manufacture is largely a pastime, the number of producers is not definitely known.

[c] Included in "Undistributed."

[d] Includes all products made by less than 3 producers in 1 State.

The number of States producing ware classed in this report as pottery in 1918 was 38, the same number as for 1917. Two States, Maine and Montana, reported no pottery for 1918, and two States, Arizona and New Mexico, entered the list as producers of Indian pottery. There are, however, only a few States that reported the higher grades of ware. In 1918 New Jersey, Ohio, and Pennsylvania each reported every kind of ware classified in this report, and New York reported every kind except stoneware.

Ohio, the leading pottery-producing State, reported for 1918 wares valued at $25,779,654, or nearly 40 per cent of the total, an increase

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of $4,425,948, or 21 per cent, over 1917. The State's principal pottery product was white ware valued at $15,779,620, which was an increase of $2,556,794, or 19 per cent, over 1917. The value of the white ware made was 61 per cent of the value of the entire pottery output of Ohio in 1918, and the State's output of this ware was 62 per cent of the output of the country. Ohio's second product in value in 1918 was porcelain electrical supplies, valued at $3,386,555, an increase of $290,393, or 9 per cent, over 1917. Columbiana County, in which East Liverpool is located, was the leading pottery-producing county in Ohio and in the country. Its output in 1918 was valued at $11,312,660, or 44 per cent of the entire output of State, an increase of $2,166,270, or 24 per cent. The value of white ware marketed in this county in 1918 was $8,951,430, or more than half that of the State's output of white ware, an increase of $1,368,576, or 18 per cent. Mahoning County was second in value of pottery, reporting ware valued at $3,591,174. Of this sum white ware constituted $3,437,674. Summit County was third with wares valued at $2,471,074. Columbiana and Mahoning counties, Ohio, and Hancock County, W. Va., contiguous territory, form the largest pottery center of the country, a center that grew out of the pottery industry started at East Liverpool, Ohio, in 1840. The value of the pottery marketed in these three counties in 1918, mostly all of the higher grades, was more than $17,000,000.

New Jersey was the second largest pottery-producing State. For 1918 it reported wares valued at $12,570,842, a small increase—$34,999—over 1917. This small gain in the value of pottery in New Jersey was due to the fact that the principal pottery product of the State is sanitary ware, which showed a considerable decrease there, as well as in most of the other States. New Jersey's output of sanitary ware was valued at $6,151,752, a decrease of $1,050,919, or 15 per cent. Sanitary ware constituted 49 per cent of the value of the State's production of pottery in 1918, and New Jersey reported 55 per cent of the entire output. Mercer County, in which Trenton is located, led in 1918 with wares valued at $10,219,282, or more than 81 per cent of the State's total, a decrease of $230,455, or 2 per cent. Sanitary ware was the chief product, valued at $5,329,846, or 52 per cent of the county's output of pottery. Middlesex County was second with products valued at $1,187,875, an increase of $199,457, or 20 per cent over 1917.

West Virginia ranks third among the pottery-producing States in value of output, and reported over 13 per cent of the total for 1918. Its pottery products (valued at $8,693,206 in 1918) increased $1,449,306, or 20 per cent. over 1917. White ware, West Virginia's principal pottery product, was valued at $5,480,581, an increase of $1,059,564, or 24 per cent. White ware constituted 63 per cent of the total value of West Virginia's pottery products in 1918. It is also a large producer of sanitary ware and reported 12 per cent of the entire output, which showed a small decrease in 1918. Hancock County, the northernmost county in the panhandle of West Virginia, just opposite East Liverpool, marketed pottery wares in 1918 valued at $4,630,302, or 53 per cent of the State's total, an increase of $941,450, or 26 per cent over 1917. Nearly all this output ($4,544,432) was white ware.

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New York was fourth in value of pottery products and Pennsylvania fifth, as for many years. New York's chief pottery product was porcelain electrical supplies, of which it was the principal producer, displacing Ohio and reporting wares valued at $3,595,478, an increase of $1,577,115, or 78 per cent, over 1917. It was also the leading china-producing State, displacing New Jersey, its output in 1918 being valued at $1,964,688, an increase of $389,726, or 25 per cent, over 1917. Schenectady and Onondaga counties were the leading ones in the value of pottery, in the order named, and reported wares valued at $3,991,483, or two-thirds of the State total. These two counties reported porcelain electrical supplies as valued at $2,299,323, an increase of $1,399,322, or 155 per cent, over 1917. Onondaga county is the largest producer of china and Schenectady county is the largest producer of porcelain electrical supplies.

The first five States, Ohio, New Jersey, West Virginia, New York, and Pennsylvania, reported wares valued at $56,534,495, or nearly 87 per cent of the total. The same States reported for 1917 wares valued at $48,405,210, or 86 per cent of the total.

In considering the rank of States it should be borne in mind that the small number of producers in many of them in 1917, which makes it impossible to publish State totals without disclosing individual returns, makes the rank of all but the first few the relative and not the actual rank.

Red earthenware, which consists principally of flowerpots, was reported from 30 States, a net decrease of 1—Montana and Tennessee reported none, and Virginia entered the list of producers. Ohio, as for many years, was the leading producer, reporting more than one-third of the total and showing an increase of $44,847, or 16 per cent, over 1917. Pennsylvania was second and Massachusetts third. These three States reported nearly two-thirds of the total for 1918. The number of operators reporting this ware (102) decreased by 19 compared with 1917.

Stoneware, including yellow and Rockingham ware, was reported by 19 States, a decrease of 1—Maine. Ohio reported nearly one-half of the output and was the leading State. Its output in 1918 was greater by $298,689, or 17 per cent, than that of 1917. The number of operators reporting these wares decreased by 7.

Chemical pottery—that is, chemical porcelain and chemical stoneware—was reported from 8 States, the same number as in 1917. Indiana and Michigan reported none for 1918 and Iowa and Tennessee entered the list of producers. Chemical porcelain valued at $221,931, an increase of $54,412 over 1917, was reported from only two States in 1918—Colorado and Ohio. New Jersey was the leading State in value of chemical pottery, as in 1917, by a small margin, and Ohio was second. New Jersey's output was valued at $745,741, an increase of $273,060, or 58 per cent, and Ohio's output was valued at $714,456, an increase greater even than that of New Jersey, $285,007, or 66 per cent. These two States reported nearly 83 per cent of the total. Eighteen operators reported chemical pottery—a decrease of 1.

The pottery products of the United States having the largest total value are grouped under the head of white ware. These include the bulk of the various household wares and constituted in 1918 nearly 39 per cent of the value of all pottery products. These wares were

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reported by 64 operators, the same number as for 1917, in 13 States, an increase of two in the number of States—California and New Hampshire. As there were less than three operators reporting sales in each of 8 States, totals for only 5 States are published in order to avoid disclosing confidential reports. Ohio was the leading State in 1918, as for many years, and reported wares valued at $15,779,620, or 62 per cent, of the total value, an increase of $2,556,794, or 19 per cent, over 1917. Of the 64 operators reporting for 1918, 37 were in Ohio. West Virginia was second in value of white ware and showed an increase of $1,059,564, or 24 per cent. New Jersey was third, with an increase of $198,372, or 19 per cent. These three States reported white ware valued at $22,499,270, or 89 per cent of the total for the entire country.

China was reported from the same five States as in 1917. New York was the leading State, displacing New Jersey, which was second. New York reported china valued at $1,964,688, an increase of $389,726, or 25 per cent, over 1917. New York reported 31 per cent of the total value in 1918. New Jersey showed a small decrease from 1917. These two States reported 56 per cent of the total. One more operator reported china in 1918 than in 1917, making the total 19, the largest number of operators reporting this ware.

Sanitary ware was reported from the same 11 States, as in 1917. New Jersey, as for many years, was the leading State, reporting ware valued at $6,151,752, or 55 per cent of the total. West Virginia was second and Indiana third. These relative ranks have been maintained for many years. These three States reported 76 per cent of the total output. All of them reported decreases—New Jersey, $1,050,919, or 15 per cent; West Virginia, $30,966, or 2 per cent; and Indiana, $172,793, or 13 per cent. Ohio, the fourth State in value of output, showed a small increase, $39,594, or 4 per cent.

Porcelain electrical supplies were reported by 11 States, a gain of one—California. New York was the leading State in the value of these wares, displacing Ohio, which was second. New York's output was valued at $3,595,478, an increase of $1,577,115, or 78 per cent, over 1917. Ohio, with products valued at $3,386,555, showed a gain of $290,393, or 9 per cent. New Jersey, which was third, with products valued at $2,437,133, increased $543,751, or 29 per cent, over 1917. These three States reported 75 per cent of the total value. The number of operators reporting porcelain electrical supplies in 1918 was 46, an increase of 2.

CONSUMPTION.

The value of pottery imported into the United States in 1918, added to that of the domestic pottery marketed, amounted to a total of $71,616,531. After deducting from this sum the value of the exports of domestic wares, approximately $1,479,552, and of the reexports of foreign ware, $70,099, the value of the apparent net consumption was $70,066,880, of which the domestic production was 93 per cent, the highest proportion recorded. In 1917 and 1916 it was 92 per cent. In 1915 this percentage was 86; in 1914 it was 82; and in 1913 it was 80.

IMPORTS.

The total value of imports of all clay products at the port of shipments ($6,684,200) increased $41,627, or less than 1 per cent, com-

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pared with 1917. In 1917 there was an increase of $876,908, or 15 per cent, compared with 1916, and in 1916 there was a decrease of $1,034,222, or 15 per cent. The value of imports in 1918 compared with 1907, the year of greatest value, decreased $7,126,732, or nearly 52 per cent. The increase in 1918 was in pottery, the brick and tile products showing a small decrease compared with 1917. Of the imports for 1918, 96 per cent was pottery and the remainder brick and tile. The value of the imports of pottery in 1918 increased $60,266, or not quite 1 per cent; in 1917 this increase was $732,729, or 13 per cent, compared with 1916. Imports of three kinds of pottery, earthenware, crockery plain and decorated, and plain china, increased in value, and brown earthenware, tobacco pipes, decorated china, and sanitary ware decreased in value compared with 1917.

Decorated earthenware showed the largest increase, $187,336, or nearly 10 per cent. Decorated china showed the largest decrease, $140,519, or 4 per cent. In 1918 the imports of the higher grades of pottery constituted 93 per cent of the total. Brick and tile imports decreased $18,639, or 6 per cent, in 1918, compared with 1917.

The data available indicate that the volume of imports was considerably less in 1918 than in 1917.

Value of clay products imported and entered for consumption in the United States, 1909–1918.

Year.	Pottery.								Brick, fire brick, tile, etc.	Grand total.
	Brown earthen and common stone ware.[a]	Tobacco pipes and pipe bowls of clay.	Earthenware and crockery composed of a nonvitrified absorbent body.		China and porcelain.		Sanitary earthenware, decorated and not decorated.	Total.		
			Not decorated.	Decorated.	Not decorated.	Decorated.				
1909....	$98,716	.....	.....	.....	$1,245,479	$9,263,017	.....	$10,607,212	$189,536	$10,796,748
1910....	154,614	$52,077	.....	.....	1,293,986	9,682,558	.....	11,183,235	222,183	11,405,418
1911....	164,871	61,244	.....	.....	1,221,756	9,251,989	.....	10,699,860	208,966	10,908,826
1912....	152,166	66,292	.....	.....	1,094,152	8,309,212	.....	9,621,822	215,379	9,837,201
1913....	238,611	31,806	[b] $81,978	[b] $523,803	[c] 1,067,209	[c] 8,273,681	.....	10,217,088	276,677	10,493,765
1914....	312,934	40,548	438,460	1,968,561	727,725	4,910,365	.....	8,398,593	207,644	8,606,237
1915....	227,017	15,155	272,795	1,538,732	458,302	4,116,085	.....	6,628,086	171,801	6,799,887
1916....	264,715	10,378	173,192	1,669,712	289,219	3,177,998	$15,371	5,600,585	165,080	5,765,665
1917....	518,965	8,209	235,104	1,960,150	157,658	3,409,527	43,701	6,333,314	309,259	6,642,573
1918....	436,207	4,716	317,501	2,147,486	200,328	3,269,008	18,334	6,393,580	290,620	6,684,200

[a] Including Rockingham ware and miscellaneous pottery products.
[b] Figures cover period from Oct. 4 to Dec. 31.
[c] Including wares classified under the act of 1913 as china and porcelain wares composed of a vitrified nonabsorbent body: Not decorated, $244,933; decorated, $2,204,851. After 1913 only wares composed of a vitrified nonabsorbent body are included.

EXPORTS.

The value of exports of domestic clay products in 1918 increased $979,311, or 14 per cent, over 1917 and reached its maximum. Of the exports 72 per cent was brick and tile, 19 per cent was pottery, and 9 per cent was unclassified. Brick and tile, valued at $5,700,371, increased $1,042,196, or 22 per cent, compared with 1917. Exports of domestic pottery, valued at $1,479,552, decreased $72,431, or 5 per cent.

Three kinds of ware and "all other" products exported in 1918 increased in value when compared with 1917, namely, fire brick,

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$989,511, or 25 per cent; tile, except drain, $131,629, or 29 per cent; sanitary ware, $53,969, or 17 per cent; and "all other" wares, $9,546, or 14 per cent. Both building and fire brick decreased in number, the former 5,393,000 brick, or 45 per cent, and the latter 11,927,000 brick, or 12 per cent. Exports of building brick, earthenware, and china decreased in value in 1918, compared with 1917. The decrease in the value of building brick was $78,944, or 40 per cent, earthenware $22,207, or 3 per cent, and china $104,193, or 25 per cent. Exports of fire brick and sanitary earthenware reached their maximum value in 1918. The average price per thousand for building brick exported was $16.25 in 1917, and $17.56 in 1918; for fire brick $39.51 in 1917, and $55.81 in 1918.

Value of clay products of domestic manufacture exported from the United States, 1909–1918.

Year.	Building brick.	Fire brick.	Tile (except drain).	Earthen and stone ware.	China.	Sanitary earthenware.	All other.	Total.
1909	.....	[a]$1,002,270	.....	$776,842	$86,853	.....	$147,622	$2,013,587
1910	.....	[b] 634,775	.....	928,475	113,214	.....	968,138	2,644,602
1911	.....	1,057,725	.....	1,278,892	122,474	.....	1,206,629	3,665,720
1912	[b]$448,939	1,117,161	[b] $539,116	1,037,637	140,147	.....	1,717,895	5,000,895
1913	689,515	1,121,590	851,463	410,050	149,281	.....	1,566,340	4,788,239
1914	524,239	734,134	658,695	390,693	136,209	.....	1,134,035	3,578,005
1915	279,336	975,089	276,785	297,127	160,710	[b] $105,615	610,578	2,705,240
1916	189,668	2,406,184	403,184	600,347	262,119	214,076	779,922	4,855,530
1917	196,207	4,011,546	450,422	805,784	422,641	323,558	743,105	6,953,263
1918	117,263	5,001,057	582,051	783,577	318,448	377,527	752,651	7,932,574

[a] Includes all brick other than building brick. [b] Figures cover period from July 1 to Dec. 31.

Clay products of domestic manufacture exported from the United States in 1917 and 1918, by countries.

	Building brick.		Fire brick.		Tile (except drain).	Earthen and stone ware.	China.	Sanitary earthenware.	All other.	Total value.
	Quantity (thousands).	Value.	Quantity (thousands).	Value.	Value.	Value.	Value.	Value.	Value.	
1917.										
Europe	440	$33,151	4,840	$430,965	$2,829	$22,044	$5,375	$9,139	$28,213	$531,716
Central America and West Indies	1,700	35,371	9,154	431,327	217,827	238,002	100,747	136,268	157,396	1,316,938
Canada	7,877	104,945	78,935	2,491,174	116,832	385,041	115,590	72,961	409,518	3,696,061
Mexico	2,031	22,491	4,910	221,210	16,472	64,390	61,519	26,104	34,931	447,117
Newfoundland	.....	.....	52	1,997	1,057	870	3,886	1,623	478	9,911
South America	19	189	2,980	328,833	82,816	74,736	109,299	52,765	50,786	699,424
Asia	.....	.....	499	93,746	8,940	11,833	16,687	10,830	53,117	195,153
Oceania	4	44	165	12,294	2,746	8,489	8,782	13,868	8,350	54,573
Africa	1	16	.....	.....	903	379	756	.....	316	2,370
	12,072	196,207	101,535	4,011,546	450,422	805,784	422,641	323,558	743,105	6,953,263
1918.										
Europe	.....	.....	1,449	130,626	7,752	11,455	8,162	10,590	25,970	194,555
Central America and West Indies	692	22,036	8,783	399,381	226,687	214,473	121,571	155,999	238,097	1,378,244
Canada	4,765	74,613	71,904	3,832,297	170,457	346,798	46,464	34,240	254,134	4,759,003
Mexico	1,149	18,565	4,291	262,141	20,074	75,204	64,567	29,206	37,369	507,126
Newfoundland	.....	.....	1	228	9,790	1,710	3,796	1,081	961	17,566
South America	70	1,959	2,002	277,786	84,919	82,379	61,498	52,437	75,565	636,543
Asia	.....	.....	964	77,084	40,268	16,850	4,884	71,845	69,795	280,726
Oceania	3	90	214	21,514	22,034	31,930	7,362	21,637	48,669	153,236
Africa	.....	.....	.....	.....	70	2,778	144	492	2,091	5,575
	6,679	117,263	89,608	5,001,057	582,051	783,577	318,448	377,527	752,651	7,932,574

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Canada continues to afford the greatest market for clay products exported from the United States, wares representing 60 per cent of the value of exports going to that country, an increase of $1,062,942, or 29 per cent, compared with 1917. Canada was the best customer for American fire brick, 80 per cent of the exports going to that country; it also took 71 per cent of the building brick exported. Central America and the West Indies are the next largest consumers of American clay products, these countries taking wares valued at $1,378,244, or 17 per cent of the total in 1918, and increase of $61,306, or 5 per cent, compared with 1917. Central America and the West Indies were the best customers for tile (except drain), sanitary ware, and china. South America was third, but the exports (valued at $636,543) decreased in value $62,881, or 9 per cent. Value of exports to Europe and Mexico decreased, the former from $531,716 in 1917 to $194,555 in 1918, a decrease of $337,161, or 63 per cent. This decrease is not surprising in view of the demand on shipping for the transportation of men and munitions of war to Europe during 1918.

CLAY.

GENERAL CONDITIONS.

Clay available for the manufacture of clay products is one of the most widely distributed minerals. Hence there are clay-working plants in every State in the Union. Miners of the lower-grade clays are usually also the manufacturers, but as the higher grades of ware are reached the rule is that fewer and fewer manufacturers are also miners, until in the highest grades of ware nearly every manufacturer buys the clays he uses. The figures given in the following tables represent clay that is mined and not burned into clay products by the miner but is sold as clay. The clay thus sold is small in quantity compared with the total production and includes mainly clay used for high-grade pottery and tile, for paper making, and for refractory products.

The conditions in the clay-mining industry in 1918, as in other industries, were most unusual. As in 1917, the industry suffered from shortage and high cost of labor and from lack of transportation facilities, which curtailed production and prevented a wider use of domestic clay. Early in the year the Shipping Board in studying the means of conserving shipping for military use contemplated placing an embargo on kaolin or china clay coming from England. In March, 1918, a conference between the users of kaolin and the miners of domestic white clays was held in Washington for the purpose of ascertaining the ability of the white-clay consuming industries to substitute domestic for imported clay. After a full discussion of the subject no embargo on clay was recommended by the Shipping Board. It was shown at the conference that for certain purposes, notably in the coating of high-grade book paper and in the paint and oilcloth industries, imported clay must be used to maintain the standard of quality and economical production. The chief obstacle, it was stated, to the use of domestic clays is their lack of uniformity in quality, which was caused chiefly by lack of or improper preparation, though English clays, it is claimed by some users, have inherent qualities that are not found in the known domestic clays. It was also brought out at this conference that had it been possible to obtain

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acceptable domestic clays from the southern Appalachian region, the chief domestic source of supply of white clay, the material could not have been marketed on account of lack of transportation facilities. In fact, the potters were willing to use more—but not a greater proportion—of domestic kaolin could it have been obtained.

The imports of clay, on the whole, decreased in quantity, compared with 1917, and were the smallest since 1904. The quantity imported in 1918 was 51 per cent less than that of 1914, the year of maximum imports. The value of the clay imported in 1918 was the smallest since 1915, and was $968,642, or 42 per cent, less than that of 1914. Under kaolin or china clay in the imports are included clays used in the paper, pottery, paint, and other industries. In the tables of domestic production the kaolin and paper clay are separately classified. Therefore to make a fair comparison between the imported and the domestic kaolin, the paper clay and the domestic kaolin should be added together. For 1918 they amounted to 179,694 short tons, valued at $1,459,529, as compared with 168,100 tons of imported kaolin, valued at port of shipment at $1,153,240.

FIELD EXAMINATION AND SAMPLING OF CLAY.

Another important development in the clay-mining industry was a conference in Pittsburgh, Pa., in May, 1918, between the committee on ceramic chemistry of the National Research Council and representatives of the Association of American State Geologists, various Government bureaus and war boards, for the purpose of stimulating a systematic search for ceramic raw materials of the United States. The report of the subcommittee on the field examination and sampling of clays by A. V. Bleininger and H. Ries should be of special interest to the miners and users of clays and it is quoted in part below.

In making the following recommendations regarding the field examination and sampling of clay deposits it is suggested that the geological surveys confine their attention, for the present at least, to those deposits which are located in accessible districts. Attention may also be called to the fact that certain formations are very unlikely to yield any high-grade materials. This applies to surface deposits, including floodplain, lake, estuarine, and glacial clays, ferruginous residual clays, and pre-Carboniferous formations.

The recommendations regarding field study and sampling, apply, therefore, especially to (1) plastic refractory clays, including fire clays, ball clays, and secondary kaolins, and (2) white burning residual clays.

Field examination.—The points to be considered are: (1) Location; (2) workability; (3) extent and thickness; (4) visible impurities affecting commercial value; (5) facilities for purification.

Location.—A clay deposit to be workable should be situated fairly close to lines of transportation. In general, commercial deposits should be located not farther than 6 miles from transportation lines.

Workability.—A deposit must be worked either by open pit or underground methods. In the first case the amount of overburden in proportion to the thickness of the deposit must not be excessive and should not in any case exceed 25 feet for a deposit at least 10 or 12 feet in thickness. For thinner deposits the overburden must be proportionately less. The character of the overburden must be considered with reference to its utilization for concrete, building sand, gravel, or the production of common-clay products.

For underground mining we must consider the character of the roof and floor, as well as the thickness of the bed. Without a good roof, mining becomes both costly and dangerous. To be workable by underground method the clay or shale bed should be not less than 4 feet and preferably 5 to 6 feet thick. For trackage purposes the last-named figure is essential. Where it is possible to mine coal in conjunction with the clay, a thinner seam may be workable. Some deposits are workable by circular or square shafts, lined with cribwork. The question of drainage, whether natural or artificial, should also be considered.

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Extent and thickness.—These points should be carefully determined for the purpose of estimating the tonnage. Careful measurements should be made of the thickness of the deposit, wherever outcrops can be found as well as where records are available. The geologic nature of the formation should also be taken into consideration, to serve as a guide for judging the persistence of the beds. By the use of levels and sections in neighboring ravines and on road cuts a continuous section can often be obtained. Where outcrops are insufficient to yield satisfactory information, borings should be made with a 2-inch auger or core. A post-hole auger may sometimes be used advantageously in digging through the overburden.

Occasionally the cooperation of the owners of the land on which the promising clay has been found can be secured in extending the sampling to boring and sinking test pits. This method gives more accurate data. This work should, however, always be done under the jurisdiction of a survey official.

Visible impurities affecting commercial value.—The impurities most easily discovered are sand, concretions of limonite, siderite, pyrite, or calcite, gypsum crystals and rosettes. Calcium carbonate may be present in a fine state of division, in which case its presence can be detected by acid. Residual clays from limestone may contain chert. These lumpy impurities can not be easily eliminated, unless the clay is washed, or unless they occur in definite bands.

Sand grains, consisting of quartz, feldspar, or mica, can be removed by washing, even if uniformly distributed through the clay, provided the clay disintegrates readily, and yields a sufficient percentage of washed product. If the clay is to be washed, to be of commercial value it should yield at least 15 per cent of refined product, provided it is of white burning character.

Facilities for purification.—In order to make washing practicable a sufficient supply of clean water should be available. There should also be a sufficient level area for location of the washing plant site, suitable space for disposal of tailings, and convenient drainage of waste water.

Sampling of deposit.—Samples are usually taken from the outcrop. This may either be an inclined or a horizontal surface. Preparatory to taking the sample, the surface must be carefully cleansed of all dirt and stained clay. Trenching 18 inches wide and 12 inches deep should, if possible, be dug across the outcrop at right angles to the strike. The spacing of the trenches is to be determined by the extent of the outcrop and uniformity of the clay. For an exposure several hundred feet in length, trenches can be dug 100 feet apart. The size of the sample is to be determined by the extent of the outcrop.

As the method outlined above will yield more material than is necessary for even a complete series of tests, the clay from the different trenches can be reduced to lumps not exceeding 2 inches in diameter, mixed together, and then reduced by quartering to about 50 pounds, which is to be sent to the testing laboratory, a lump sample of about 10 pounds being sent to the office of the Survey. The quartering should be done on a heavy sail cloth at least 6 feet square and as the amount of material is reduced, the lumps should be further broken up.

If the deposit shows distinct differences as regards structure, color, and texture, each bed showing these individual differences should be sampled separately, provided these beds are sufficiently thick to be mined by themselves, or can be thrown out if undesirable.

If the deposit is being worked and a clean face is exposed, the sampling cut can be made narrower and shallower than specified above, a sufficient number of cuts being taken to give a quantity of at least 200 pounds. Where the clay is stored in stock piles the sample may be taken from these, provided they are representative. At least one-half of the sample should be taken from the lower third of the pile. In the case of clays that are being purified, a sample of both the crude material and the clay as prepared for the market should be taken.

The samples collected as outlined above shall be placed in clean, tight-weave, strong sacks. The sample should be numbered, the number being stamped on one end of a tin or zinc tag, 3 by 1 inch. This tag is to bear the sample number and name of the Survey sending it. The tag is to be bent in half and attached to 2 feet of cord, the end of which is tied in the neck of the sack. The sack should be shipped with a linen label, bearing address and sample number and name of sender.

CLAY CONFERENCE.

Another noteworthy event of this year was the meeting in Pittsburgh, Pa., on October 15, of many miners of high-grade clays and of representatives of the War Industries Board and of the United States

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Geological Survey for the purpose of forming a war service committee. This committee was called at the suggestion of the Chamber of Commerce of the United States. The function of this committee was to afford the industry a channel through which it could keep in touch with the War Industries Board and other Government boards and departments. At this meeting a war service committee was elected, subject to the ratification by the industry, as follows: D. R. Edgar, Robert S. Finney, C. J. Hand, R. D. Hatton, F. S. Bell. J. M. Manor, Henry M. Minor, and P. J. Ryan. The armistice came so soon after this meeting that the committee was unable to accomplish anything or even to complete its organization.

HIGH-ALUMINUM CLAYS.

Inquiries for a supply of clay containing 35 per cent or more of alumina continue to come to the Geological Survey. Many such clays are known in Arkansas, California, Colorado, Georgia, Indiana, Kentucky, Mississippi, Missouri, New Jersey, Ohio, and Pennsylvania, and no doubt search in other States will find many more. The most interesting development along this line is that of the diaspore clay of the flint-clay deposits of eastern central Missouri. The preliminary report[1] on this subject is as follows:

DIASPORE CLAY IN MISSOURI.

The presence of flint clay deposits in eastern central Missouri has been known for a good many years. The principal district in which they occur includes the counties bordering Missouri River in the north and south from St. Louis County as far west as Callaway and Osage. To the south Maries, Phelps, and Crawford counties are also included.

Pockets of flint clay in large number extend from Truesdale, Warren County, past Montgomery City to Fulton, Callaway County, on the north. On the south they are even more abundant from Jeffriesburg, Franklin County, west to Belle, Maries County, and from Leasburg, Crawford County, west to Rolla, Phelps County.

The opening of the first flint clay pits dates back nearly 50 years ago, almost with the beginning of railroad transportation in the district. Since this time there has been continuous but shifting and fluctuating activity and over 100 flint clay pits have been opened. Developments have formerly and still are confined to narrow zones bordering the railroads—zones whose outer limits are determined by the balance between cost of haulage and price obtained for the clay. At present no clay is hauled farther than five miles. The productive belts border the Wabash, the St. Louis-San Francisco, and the Chicago, Rock Island & Pacific railroads. The first two roads have long been transporters of flint clays, but the Chicago, Rock Island & Pacific did not enter the field until 1902, following its extension westward from Franklin County.

The flint fire clay has always been the principal type of clay produced in this district. This varies from a comparatively soft creamy white, nonplastic clay of an oily nature, to harsh hard dull gray varieties, not unlike the mineral from which it receives its name. A light-colored plastic clay (bond clay) is quite commonly associated with the flint clay. In some pits it is a decomposition product at the top of the deposits; in others it forms the major part of the deposit.

The most recently discovered and important associate of the flint clay is diaspore clay, an aluminum-rich variety formerly discarded because of its sandy rough texture, and of the blistering and distortion it caused when fired. This type of clay has been found chiefly along the Chicago, Rock Island & Pacific Railway from Gerald west to Belle, with one or two smaller lenses in pits near Hofflins, on the St. Louis-San Francisco line. The presence of this rough type of clay has until recently been regarded as detrimental or worthless and to-day abandoned pits may be found where large bodies of it were left. The peculiar texture of the diaspore clay and its common association with the flint clay, frequently as a core near the center of the deposit or as rounded boulders in the overlying weathered clay, aroused interest of Dr. W. S. Cox,

[1] Missouri Bur. Geology and Mines Bienn. Rept. State Geologist, Fiftieth General Assembly, 1919, pp. 17-20.

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of Cuba, Mo., who had for several years been a producer of flint clay. Samples were sent by him to numerous firms for testing and valuation, and chemical analyses were obtained.

In texture diaspore clay ranges from a compact hard blue or gray flint clay with scattered flecks of white or bluish white and an occasional minute oolite through a true oolitic form to a rough, porous ash-colored mass not unlike the light-colored varieties of bauxite. Red varieties of the clay are also found. It had been discovered that where this type of clay was found there was an enrichment of alumina, depletion of silica, and frequently a very low lime and magnesia content. An analysis made on a sample of the clay by Mr. W. E. Oyler, Missouri Geological Survey, Rolla, Mo., showed the following results:

Analysis of diaspore clay from Missouri.

	Per cent.
Moisture	0.60
Loss on ignition	14.00
Silica (SiO_2)	9.30
Alumina (Al_2O_3)	73.73
Iron oxide (Fe_2O_3)	.57
Soda (Na_2O)	2.00
Potash (K_2O)	.52
	100.72

The diaspore clay is therefore quite distinct from the flint clay in both texture and composition. It is apparently made up from particles and oolites of the mineral diaspore (AlO, OH) containing 85 per cent aluminum and 15 per cent water, interbedded in more or less flint clay. This composition gives rise to the name "diaspore clay," tentatively used here.

Edgar T. Wherry, of the Bureau of Chemistry, Washington, D. C., recognized the mineral in a sample sent from Rosebud as diaspore or diasporite [1] and later wrote:[2] "The recognition of diasporite, in comparatively large masses in association with clay suggests that this mineral may possibly prove to be of commercial value, either as an ore of aluminum or for the manufacture of abrasives."

Dr. Cox has succeeded in introducing the disapore clay into a broad field of usefulness, and it promises soon to assume an important place among aluminum ores; blended with clay, it supplies the desired aluminum content in certain types of refractories; refined and bonded, it is used as an abrasive under special trade names. Shipments in commercial quantities were begun about the first of this year (1918).

The deposits are large, often forming the cores of the flint clay pockets of the Rock Island district, and in a few of those along the Frisco [lines]. As developments are extended farther out new deposits are likely to be discovered and an ample supply is assured.

Diaspore clay is generally shipped under two trade names—"Ashy clay," the rougher, porous variety richest in aluminum, the "Massillon clay," a leaner variety with fewer and smaller oolites and of a more compact texture.

An investigation of this new clay and its associations is now being carried on by the Bureau.

PRODUCTION.

The clay sold as such in 1918 amounted to 2,976,361 short tons, a decrease of 137,483 tons, or 4 per cent. This clay was valued at $8,332,641, or $2.80 a ton, an increase of $290,095, or 4 per cent, and of 22 cents in the average price. Kaolin, stoneware clay, and miscellaneous clay showed increase in output and value. No kind of clay reached its maximum output in 1918, although kaolin, paper clay, ball clay, fire clay, and miscellaneous clay, reached their maximum value in that year. The maximum value of clay marketed was attained in 1918, and the maximum quantity was reached in 1917. The increase in output of kaolin in 1918 was 6,084 tons, or 19 per cent, and the value of this material increased $89,731, or 30 per cent, compared with 1917. Stoneware clay increased in output 5,448, or

[1] Am. Mineralogist, vol. 2, pp. 144, 1917. [2] Idem, vol. 3, pp. 154, 1918.

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7 per cent, and in value it increased $33,259, or 29 per cent. Only one kind of clay—slip—decreased in output and value. Paper clay showed the largest increase in value, $105,999, or 11 per cent, except miscellaneous clays, which embrace a variety of clays. Paper clay showed a large decrease in output, 32,724 tons, or 19 per cent. This decrease was principally in Georgia. Ball clay decreased in output 17,510 tons, or 16 per cent, but increased in value $21,391, or 4 per cent. The largest decrease in output—42,939 tons, or 18 per cent, was shown by fire clay, but it increased in value $38,969, or less than 1 per cent. Fire clay ranked first in production and constituted 77 per cent of the output and 68 per cent of the value of the domestic clay marketed in 1918. Paper clay ranked second, with 5 per cent of the output and 13 per cent of the value; ball clay was third, with 3 per cent of the output and 7 per cent of the value. The average price per ton increased for every kind except slip clay. The greatest increase in price was in paper clay, $2.02, or to $7.54; ball clay increased $1.27, or to $6.57; kaolin 85 cents, or to $10.30; stoneware clay 29 cents, or to $1.69; fire clay 6 cents, or to $2.46. Slip clay decreased 47 cents a ton, from $4.15 to $3.68.

Clay marketed in the United States, 1909–1918.

Year.	Kaolin.		Paper clay.		Slip clay.		Ball clay.		Fire clay.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
1909	31,227	$241,060	81,586	$386,764	18,010	$30,527	49,074	$214,194	1,463,919	$2,082,193
1910	34,221	255,873	85,949	420,476	17,696	29,962	70,637	257,265	1,638,931	2,157,720
1911	27,400	221,045	69,265	454,435	8,393	16,770	65,072	220,710	1,526,921	2,112,827
1912	25,852	220,747	119,857	522,924	16,339	27,573	64,939	227,545	1,695,337	2,363,357
1913	28,834	235,457	126,377	567,977	10,902	24,505	67,134	237,672	1,820,379	2,592,591
1914	34,191	284,817	116,328	558,334	8,237	17,731	67,927	255,767	1,409,467	2,147,277
1915	28,031	241,520	113,033	539,622	7,646	18,774	75,348	301,910	1,570,481	2,361,482
1916	47,723	306,819	153,434	768,911	14,064	47,939	89,761	391,152	2,057,814	3,706,009
1917	31,885	301,378	174,419	962,421	16,972	70,505	107,406	569,240	2,347,972	5,625,095
1918	37,969	391,109	141,725	1,068,420	13,552	49,898	89,896	590,631	2,305,033	5,664,064

Year.	Stoneware clay.		Brick clay.		Miscellaneous clay.		Total.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
1909	130,757	$137,264	222,686	$171,183	162,388	$186,522	2,159,647	$3,449,707
1910	152,942	153,044	173,625	128,039	215,228	223,106	2,389,229	3,625,485
1911	151,384	165,751	142,020	123,900	162,243	165,325	2,182,698	3,480,763
1912	124,409	115,522	229,306	204,504	254,226	263,848	2,530,265	3,946,020
1913	153,353	143,587	158,890	137,976	282,120	240,694	2,647,989	4,180,459
1914	130,383	116,610	199,154	161,852	244,173	214,180	2,209,960	3,756,568
1915	134,207	126,429	101,968	93,863	332,150	288,341	2,362,954	3,971,941
1916	135,958	137,779	97,164	76,854	336,672	314,311	2,932,590	5,751,774
1917	81,352	113,839	93,779	94,703	260,029	305,365	3,113,844	8,042,546
1918	85,800	147,098	(a)	(a)	301,386	421,421	2,976,361	8,332,641

a Included in miscellaneous.

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Clay marketed in the United States in 1917.

State.	Kaolin.		Paper clay.		Slip clay.		Ball clay.		Fire clay.		Stoneware clay.		Brick clay.		Miscellaneous clay.[a]		Total.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Alabama							(b)	(b)	41,951	$67,674			(b)	(b)			58,667	$84,763
Arizona									(b)	(b)							(b)	(b)
California	(b)	(b)					(b)	(b)	91,589	95,346	7,372	$8,155	(b)	(b)	23,508	$21,808	137,892	151,348
Colorado	(b)	(b)			(b)	(b)			97,393	95,375	(b)	(b)	7,873	$6,451			106,775	103,376
Connecticut													(b)	(b)			(b)	(b)
Delaware	(b)	(b)							(b)	(b)							11,243	85,330
Florida							(b)	(b)									(b)	(b)
Georgia			109,222	$573,707	(b)	(b)			1,727	5,652	(b)	(b)			(b)	(b)	187,355	599,359
Idaho									(b)	(b)							(b)	(b)
Illinois			(b)	(b)					150,655	736,568	32,327	35,752			(b)	(b)	195,698	789,589
Indiana	(b)	(b)							71,564	72,605			(b)	(b)	250	1,750	73,863	78,463
Iowa									(b)	(b)					5,426	2,764	5,488	3,012
Kentucky					(b)	(b)	17,858	$98,736	70,276	213,819	(b)	(b)			3	50	91,727	320,365
Maryland	(b)	(b)							37,274	107,557			(b)	(b)	1,000	200	42,364	114,027
Massachusetts									(b)	(b)			532	401	15	28	847	1,329
Michigan					2,153	$8,824							(b)	(b)			5,746	13,627
Minnesota															(b)	(b)	(b)	(b)
Mississippi									(b)	(b)							(b)	(b)
Missouri	573	$3,992							491,674	1,306,721	(b)	(b)			(b)	(b)	497,267	1,386,338
Montana									7,083	26,710							7,083	26,710
Nebraska									(b)	(b)	(b)	(b)			(b)	(b)	1,980	4,412
Nevada	(b)	(b)															(b)	(b)
New Jersey					(b)	(b)	5,118	28,264	281,098	815,507	12,041	39,326	38,563	46,204	43,475	106,125	380,362	1,035,703
New Mexico									2,269	8,931							2,269	8,931
New York					(b)	(b)			(b)	(b)					1,714	1,955	11,894	51,505
North Carolina	(b)	(b)									(b)	(b)	(b)	(b)			17,426	182,176
North Dakota									(b)	(b)							(b)	(b)
Ohio					2,675	4,840			349,526	529,840	20,464	18,886	(b)	(b)	19,663	9,758	398,796	568,687
Oregon									(b)	(b)	(b)	(b)					(b)	(b)
Pennsylvania			25,014	217,008					441,344	1,118,343	(b)	(b)	8,143	4,602	34,382	21,859	511,405	1,365,870
South Carolina			40,173	171,506					(b)	(b)							40,448	173,706
South Dakota															(b)	(b)	(b)	(b)
Tennessee							40,282	166,589	58,153	107,347	(b)	(b)			8,000	6,000	106,535	280,136
Texas									4,059	22,257	(b)	(b)			87	175	4,446	22,477
Utah									4,079	8,298							4,079	8,298
Vermont	(b)	(b)							(b)	(b)					32	140	2,766	27,032
Virginia	(b)	(b)							(b)	(b)			(b)	(b)			3,724	6,263
Washington					(b)	(b)			779	7,159	(b)	(b)					1,613	9,248

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West Virginia	.....	.....	.....	.....	.....	.....	.....	.....	.....	127,024	189,672	.....	.....	.....	.....	.....	.....	127,024	189,672
Wisconsin	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(b)	(b)
Wyoming	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(b)	(b)
Undistributed c	31,312	287,386	40	200	12,144	16,972	70,505	56,841	44,143	275,651	18,455	89,714	9,148	11,720	38,668	37,045	122,474	132,753	79,067	350,794
	31,885	301,378	174,449	962,421	.....	.....	4.15	.....	.....	5.30	2,847,972	5,625,096	81,352	113,839	93,779	94,708	260,029	305,365	3,113,944	8,042,646
Average price per ton	.....	9.45	.....	5.52	.....	.....	.....	.....	.....	.....	.....	2.40	.....	1.40	.....	1.01	.....	1.17	.....	2.66

a Including bentonite, modeling clay, sewer-pipe clay, and terra-cotta clay.
b Included in "Undistributed."
c Includes all clay reported by less than 3 producers in 1 State.

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Clay marketed in the United States in 1918.

State.	Kaolin.		Paper clay.		Slip clay.		Ball clay.		Fire clay.		Stoneware clay.		Miscellaneous clay.[a]		Total.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Alabama									49,516	$48,611			532	$582	50,048	$49,193
Arizona									(b)	(b)					(b)	(b)
California	1,427	$26,104					(b)	(b)	103,059	162,644	3,019	$3,900	44,486	47,743	152,311	241,420
Colorado									97,546	117,418			698	516	98,244	117,934
Connecticut													(b)	(b)	(b)	(b)
Delaware	3,610	53,923							(b)	(b)					9,039	62,981
Florida							(b)	(b)							(b)	(b)
Georgia			76,073	$552,083					2,073	7,665			(b)	(b)	140,675	641,283
Idaho									(b)	(b)					(b)	(b)
Illinois									133,585	372,295	32,163	38,343	3,434	3,263	169,182	413,901
Indiana	(b)	(b)							52,675	76,234	(b)	(b)	50,792	45,032	104,396	131,324
Iowa									(b)	(b)			5,401	3,585	5,416	3,705
Kentucky							19,627	$113,019	71,439	213,402			301	896	91,367	327,317
Maryland	(b)	(b)					(b)	(b)	12,654	50,132			600	180	23,254	65,387
Massachusetts					(b)	(b)			(b)	(b)			1,348	3,892	2,176	6,373
Michigan					1,236	$4,639							(b)	(b)	2,359	6,373
Minnesota													(b)	(b)	(b)	(b)
Mississippi	(b)	(b)							3,863	27,185			153	242	4,066	28,027
Missouri	(b)	(b)							452,792	1,101,652			10,063	79,528	464,446	1,192,996
Montana									9,418	24,503					9,418	24,503
Nebraska									(b)	(b)	(b)	(b)	21	42	1,351	2,463
Nevada	180	1,805													180	1,805
New Jersey					(b)	(b)	5,828	33,347	240,268	918,390	13,655	51,202	26,685	65,490	286,474	1,068,572
New Mexico									4,213	13,488					4,213	13,488
New York					(b)	(b)			(b)	(b)			621	924	10,120	41,541
North Carolina	(b)	(b)									(b)	(b)			16,054	222,205
North Dakota									(b)	(b)					(b)	(b)
Ohio					2,654	5,685			347,686	683,533	34,430	45,601	20,583	9,396	405,353	744,215
Oregon									(b)	(b)	(b)	(b)			(b)	(b)
Pennsylvania			27,611	256,159					529,487	1,403,545	(b)	(b)	33,500	34,580	591,685	1,697,228
South Carolina			38,041	260,178					(b)	(b)					38,311	262,878
South Dakota													(b)	(b)	(b)	(b)
Tennessee					(b)	(b)	33,025	193,903	52,461	151,784			3,400	4,250	88,962	350,333
Texas									2,710	13,399	(b)	(b)	70	280	2,980	13,879
Utah									7,533	22,528					7,533	22,528
Vermont	(b)	(b)							(b)	(b)					(b)	(b)
Virginia	(b)	(b)							(b)	(b)			3,026	1,520	9,003	32,923
Washington					(b)	(b)			1,795	9,853			(b)	(b)	3,435	17,637

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West Virginia									120,437	216,771					120,437	216,771
Wisconsin													(b)	(b)	(b)	(b)
Wyoming													(b)	(b)	(b)	(b)
Undistributed [c]	32,752	309,277			9,662	39,574	31,416	250,362	9,823	29,032	3,533	8,052	95,672	119,480	63,873	311,458
	37,969	391,109	141,725	1,068,420	13,552	49,898	89,896	590,631	2,305,033	5,664,064	86,800	147,098	301,386	421,421	2,976,361	8,332,641
Average price per ton		10.30		7.54		3.68		6.57		2.46		1.69		1.40		2.80

[a] Including bentonite, brick clay, leverrierite, modeling clay, sewer-pipe clay, terra-cotta clay, and bog clay used in lead-pencil manufacture.
[b] Included in "Undistributed."
[c] Includes all clay reported by less than 3 producers in 1 State.

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Forty-one States, as in 1917, reported sales of clay in 1918, and the leading seven States, as in 1917, in the order of quantity of clay marketed, were Pennsylvania, Missouri, Ohio, New Jersey, Illinois, California, and Georgia, except that in 1917 Georgia was sixth and California was seventh. These seven States reported 2,210,126 tons of clay, in 1918, or 74 per cent of the total; their output in 1917 was 2,306,770 tons, also 74 per cent of the total; and the decrease in 1918 was 96,644 tons, or 4 per cent, compared with 1917. In value of output the leading seven States were Pennsylvania, Missouri, New Jersey, Ohio, Georgia, Illinois, and Tennessee. The value of the clay marketed in these States in 1918 was $6,108,528, or 73 per cent of the total; in 1917 the value was $6,025,682, or 75 per cent of the total. In all these States, except Georgia and Tennessee, fire clay was the principal product in 1918. In Pennsylvania fire clay constituted 89 per cent of the output and 83 per cent of the value of the clay marketed; in Missouri it was 97 per cent of the output and 92 per cent of the value; in Ohio, 86 per cent of the output and 92 per cent of the value; in New Jersey, 84 per cent of the output and 86 per cent of the value; and in Illinois, 79 per cent of the output and 90 per cent of the value. In Georgia the principal clay marketed was the well-known white "plastic kaolin" or paper clay of the central part of the State, 54 per cent of the output and 86 per cent of the value of the State total being of that variety.

Fire clay.—Fire clay was reported from 32 States. In 1918, Pennsylvania was the leading State, displacing Missouri, the leading State in 1917. Pennsylvania's output in 1918 was 529,487 tons, or 23 per cent of the total, and was valued at $1,403,545, or 25 per cent of the total. This was an increase of 88,143 tons, or 20 per cent, and of $285,202, or 26 per cent, compared with 1917. Missouri's output of fire clay in 1918 was 452,792 tons, or 20 per cent of the total, a decrease of 38,882 tons, or 8 per cent; the value was $1,101,652, or 19 per cent of the total value, and a decrease of $205,069, or 16 per cent. Of the production of fire clay in Missouri in 1918 St. Louis City and St. Louis County reported 338,564 tons, valued at $902,001, or 75 per cent of the State's output and 82 per cent of its value, a decrease of 67,684 tons, or 17 per cent, and of $271,661, or 23 per cent, compared with 1917. Ohio was third in output and fourth in value. Its output was 15 per cent of the total and was 347,686 tons, a decrease of 1,840 tons, or less than 1 per cent, and its value was $683,533, an increase of $153,693, or 29 per cent. New Jersey, as in 1917, was fourth in output and third in value of fire clay, the State reporting 240,268 tons, or 10 per cent of the total, valued at $918,390, a decrease in quantity of 40,830 tons, or 15 per cent, but an increase of $102,883, or 13 per cent, in value. Middlesex County is the great fire-clay producing center of the State, and 207,459 tons, or 86 per cent of the State's total, was reported from that county. Illinois was fifth in output and value, reporting 6 per cent of the total output and 7 per cent of the total value. In Illinois the output, which was 133,585 tons, decreased 17,070 tons, or 11 per cent, and the value decreased $364,273, or 49 per cent, compared with 1917. The average price per ton of fire clay in 1918 in these States was: Illinois, $2.79; Missouri, $2.43; New Jersey, $3.82; Ohio, $1.97; and Pennsylvania, $2.65; in 1917 the corresponding prices were: Illinois, $4.89; Mis-

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souri, $2.66; New Jersey, $2.90; Ohio, $1.52; and Pennsylvania, $2.53. It thus appears that in only one of these States, Illinois, was there a large decrease in average price. This was caused by the decreased demand for clays from Illinois suitable for crucibles and other high-grade products for which a very high price had been obtained.

Kaolin.—Kaolin, the purest form of clay and in some respects the most valuable, was reported from 10 States, the same number as for 1917. Colorado, which reported kaolin in 1917, reported none for 1918, and Mississippi appeared as a producer. On account of the small number of producers in seven of these States it is impossible to publish figures of production without disclosing confidential information. The principal source of domestic kaolin is the Southern States, which reported seven-eighths of the output. North Carolina was the largest producer and reported nearly one-half of the output and value.

Paper clay.—Paper clay, the second clay in output, value, and average price per ton, whose principal use is indicated by its name, was reported from three States, a decrease of one—Illinois. Georgia was the leading producer and reported 54 per cent of the output and 52 per cent of the value, a decrease of 33,149 tons, or 30 per cent, and of $21,624, or 4 per cent. The average price per ton in Georgia increased $2.01 to $7.26. South Carolina was also a large producer of paper clay, these two States reporting 81 per cent of the output in 1918. The decrease in output in 1918 was due largely to the lack of transportation facilities to move the material to the markets in the Northern States.

Ball clay.—A plastic white-burning clay that finds its principal use in white-ware bodies, was reported from six States in 1918, the same number as in 1917, but Alabama dropped out and Maryland entered the list of producers. The Southern States produced nearly the entire output in 1918, 93 per cent of the output coming from that region. Tennessee was the leading State. It reported 37 per cent of the output and 33 per cent of the value, a decrease of 7,257 tons, or 18 per cent, but an increase in value of $27,314, or 16 per cent. The average price per ton increased in this State $1.73 to $5.87.

PRODUCTION BY USES.

In response to a considerable demand for information in regard to the uses to which domestic clays are put an effort was made to obtain such data for 1918. As with all new statistical investigations where the data are derived from voluntary reports by correspondence, the result of the first canvass is not entirely satisfactory, though it is believed that the data given in the following table are sufficiently accurate to serve as a guide in a study of the uses of domestic clays. The principal obstacle to obtaining satisfactory data is that many producers do not know the uses to which the clays they ship are put. This is especially true of clay that is sold through brokers, such as much high-grade clay. Some of the miners may know in a general way the purposes for which their clay is adapted but could not give definite figures of the quantity sold for each use, and many of them do not appear to know even the uses to which their clay is adapted.

With the beginning of the publication of these data it is hoped that the miners of clay will endeavor to learn more concerning the utility

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of their product, as the advantage accruing from such knowledge is manifest, many clays no doubt being better suited to other uses than those to which they are put.

In considering these figures it should be borne in mind that they represent only the clay sold as clay by the original producers and do not include the much greater quantities of clay that are burned into clay products by the miners. Thus, the large quantities of clay used in the manufacture of building and paving brick, draintile, sewer pipe, fireproofing, etc., are not included. Therefore these figures are interesting chiefly in showing the clay marketed for the higher grades of wares. Apparently the largest use of clay is the use by foundries and steel works for lining converters, cupolas, ladles, etc. This use is proportionately large because probably none of the users mine the clay themselves; hence all such clay is purchased and has been reported by miners. On the other hand many if not most of the makers of fire brick mine at least a part of their clay. Therefore the clay reported for fire brick represents only a small proportion of that actually used in making this ware. Kaolin, paper clay, ball clay, slip clay, and stoneware clay being produced almost exclusively by nonmanufacturers, the figures for these clays represent practically their entire output.

A study of the table shows that 834,789 tons, or 28 per cent of the total, was used in foundries and steel works, for converter and cupola linings, etc.; 621,788 tons, or 21 per cent, in fire brick or block; 149,983 tons, or 5 per cent, in zinc retorts and condensers; and 92,114 tons, or 3 per cent, in saggers. A total of 125,321 tons, or 4 per cent, of domestic clay of all kinds was reported as having been used in high-grade pottery and tile. Of this total the white ware or general ware industry consumed 69,119 tons, porcelain electrical supplies 24,232 tons, sanitary ware 16,799 tons, and tile 11,935 tons. Stoneware and chemical stoneware consumed 80,051 tons, or nearly 3 per cent of the marketed domestic clay. The principal refractory uses, foundries, steel works, converter and cupola linings, fire brick, zinc retorts, and condensers and saggers, consumed 1,698,674 tons, or 57 per cent of the domestic clay marketed in 1918. The paper-making industry consumed 98,163 tons, or 3 per cent of the total. Other interesting uses of domestic clay, though not so large as the foregoing, are in the oilcloth, paint, and enameling industries, 2,858 tons of clay having been reported sold for making oilcloth, 8,099 tons for paint, and 599 tons for enameling. Crayons for tailors used 352 tons of domestic clay; 59,290 tons of clay was reported as having been sold for glasshouse pots, blocks, tiles, supplies, etc., and 8,475 tons for graphite crucibles, pencil leads, etc. These figures are the more interesting when it is considered that clays for many of these uses were largely imported before the war. Other unique uses of clay are in the manufacture of artificial abrasives, phonograph records, and picture molding, and in water purification, 13,197 tons having been sold for artificial abrasives, 1,629 tons for phonograph records, 25 tons for picture molding, and 250 tons for water purification. Of the clay marketed as such 18 per cent was unclassified by the miner according to uses.

Of the domestic kaolin marketed in 1918, 21,190 tons, or 56 per cent, was sold for high-grade pottery; 6,383 tons, or 17 per cent, for

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paper; and 7,500 tons, or 20 per cent, for fire brick or block. Kaolin was one of the best classified by the shippers, practically all—99.6 per cent—of the output being reported by uses.

The principal use of paper clay marketed in 1918, as indicated by its name, was in the making of paper, 89,422 tons, or 63 per cent of the total, having been shipped for that purpose. The pottery and tile industries used 25,842 tons, or 18 per cent, of the total clay of this kind. The cement industry took 7,877 tons, or 6 per cent, presumably for the manufacture of white cement. The paint industry consumed 6,654 tons, or 5 per cent. The other uses of paper clay are comparatively small, the oilcloth industry taking 2,858 tons and the phonograph industry 1,600 tons. No use was specified for 4 per cent of the paper clay marketed in 1918.

The principal use of domestic ball clay in 1918 was in the high-grade pottery and tile industries, 67,362 tons, or 75 per cent, having been sold for these uses. The next largest specified use was in saggers, for which 4 per cent of the output was reported. This clay was also reported as having been marketed for use in making glass pots, etc., fire brick, pins, stilts, and spurs for potters' uses, etc.; the use was not reported for 8,216 tons, or 9 per cent of the output.

Slip clay, an easily fusible material, found its chief use in the manufacture of artificial abrasives, 6,593 tons, or 49 per cent, going to that use, and 4,228 tons, or 31 per cent, being used for glazing. Slip clay showed the smallest proportion of unspecified shipments—0.3 per cent.

Fire clay, as its name would indicate, finds its greatest use in refractories, 96 per cent of the classified output being marketed for uses where refractoriness is the prime requisite. The term "fire clay" is elastic, and no doubt there are reported under this head clays of very little refractory value as well as fire clays of the highest grade. Hence the uses of this clay may be varied. Apparently the largest use of fire clay is in the foundries and steel works for converter and cupola linings, 809,562 tons, 35 per cent of the classified fire clay, having been marketed for those purposes. As stated elsewhere, however, this proportion is more apparent than real, for the clay used in these industries is probably all purchased, whereas much if not most of the clay used in fire brick is mined by the manufacturers, and hence would not be included in the figures here given. The clay sold for fire brick amounted to 604,704 tons, or 26 per cent, and that for zinc retorts and condensers to 149,983 tons, or 7 per cent of the total. Next to refractories and high-grade pottery and tile the largest use of fire clay was in the manufacture of terra cotta, which took 12,854 tons. Other uses to which "fire clay" has been put are in the manufacture of enamel ware, paper, paint, asbestos products, cement, artificial abrasives, crayons, and chemicals. Fire clay showed the largest proportion of unspecified clay, 20 per cent.

Stoneware clay, which is a refractory or semirefractory clay, is used chiefly, as its name would indicate, in the manufacture of stoneware and chemical stoneware, 79,481 tons, or 92 per cent, of the output going to those uses.

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Domestic clay sold in the United States in 1918, by uses, in short tons.

Uses.	Kaolin.	Paper clay.	Ball clay.	Slip clay.	Fire clay.	Stoneware clay.	Miscellaneous clay.	Total.
China, bone china, delft and belleek ware, white ware, including cream-colored white granite, semiporcelain, and semivitreous porcelain ware	19,520	22,441	26,784	.....	374	.....	.....	69,119
Hard porcelain	.....	92	1,288	.....	.....	.....	.....	1,380
Porcelain electrical supplies	110	1,442	20,398	.....	2,282	.....	.....	24,232
Sanitary ware	1,560	899	9,104	.....	5,236	.....	.....	16,799
Chemical porcelain	.....	.....	118	.....	.....	.....	.....	118
Art pottery	.....	595	890	.....	3	.....	250	1,738
High-grade tile	.....	373	8,780	1,925	723	.....	134	11,935
Chemical stoneware	.....	.....	127	.....	.....	10,197	.....	10,324
Stoneware	.....	.....	40	.....	403	69,284	.....	69,727
Enameling as coating for granite ware, etc.	100	.....	464	.....	35	.....	.....	599
Paper filler and coating	6,383	89,422	.....	.....	2,358	.....	.....	98,163
Oilcloth	.....	2,858	.....	.....	.....	.....	.....	2,858
Paint filler or extender and paint pigment	218	6,654	.....	.....	211	.....	1,016	8,099
Architectural terra cotta	.....	233	914	.....	12,854	.....	3,461	17,462
Saggers	.....	162	3,999	.....	86,796	1,157	.....	92,114
Pins, stilts, and spurs for potters' use	.....	.....	1,274	.....	732	.....	.....	2,006
Wads	.....	.....	210	.....	28,343	.....	.....	28,553
Asbestos	325	.....	.....	.....	11,103	.....	.....	11,428
Slip for glazing	.....	.....	50	4,228	.....	.....	.....	4,278
Gas retorts	.....	.....	.....	.....	2,002	.....	.....	2,002
Cement	.....	7,877	.....	.....	405	.....	20,106	28,388
Kalsomine	40	.....	.....	.....	.....	.....	.....	40
Artificial abrasives, as emery wheels, etc.	.....	40	1,452	6,593	4,512	100	500	13,197
Crayons for tailors' use	.....	216	.....	.....	136	.....	.....	352
Chemicals	.....	.....	.....	.....	73	.....	40	113
Munitions, air caisson work, fireworks for Government war signals, etc.	.....	.....	.....	342	.....	.....	124	466
Fire brick and block	7,500	463	2,500	.....	604,704	.....	6,621	621,788
Clay mortar, including clay for laying up fire brick	.....	.....	.....	.....	26,434	.....	.....	26,434
High-alumina brick	800	.....	.....	.....	.....	.....	.....	800
Glasshouse pots, and glasshouse supplies, blocks, tiles, etc.	200	.....	2,928	.....	56,162	.....	.....	59,290
Filler	.....	.....	.....	.....	.....	.....	150	150
Zinc retorts and condensers	.....	.....	.....	.....	149,983	.....	.....	149,983
Clay crucibles	.....	.....	.....	.....	300	.....	.....	300
Graphite products, crucibles, pencil leads, etc.	.....	93	360	.....	7,522	.....	500	8,475
Foundry use and steel works, for converter lining, cupola lining, etc.	.....	290	.....	6	809,562	.....	24,931	834,789
Gypsum products	1,045	.....	.....	.....	.....	.....	.....	1,045
Phonograph and disk records, etc.	29	1,600	.....	.....	.....	.....	.....	1,629
Picture molding	.....	25	.....	.....	.....	.....	.....	25
Water purification	.....	.....	.....	.....	.....	.....	250	250
Other [a]	.....	104	.....	420	28,923	963	190,669	221,079
Unspecified	139	5,846	8,216	38	462,862	5,099	52,634	534,834
Value	37,969 $391,109	141,725 $1,068,420	89,896 $590,631	13,552 $49,898	2,305,033 $5,664,064	86,800 $147,098	301,386 $421,421	2,976,361 $8,332,641

[a] Includes clay for wall plaster, tobacco pipes, toy marbles, modeling, for construction of sodium silicate furnaces, smelter purposes, for manufacture of dressing for cleaning stone and concrete, and some for brick, sewer pipe, drain and hollow tile, conduits, etc.

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IMPORTS.

Clay imported and entered for consumption in the United States, 1909–1918.

Year.	Kaolin or china clay.			Common blue and Gross-Almerode glass-pot clay.		All other clays.				Total.	
						Unwrought.		Wrought.			
	Quantity (short tons).	Value.	Average price per ton.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
1909..	246,381	$1,505,779	$6.11	12,346	$104,401	30,147	$134,978	1,906	$50,632	290,780	$1,795,790
1910..	257,902	1,503,472	6.13	21,176	181,334	27,890	113,352	1,496	26,205	308,464	1,914,363
1911..	255,107	1,461,068	5.73	17,193	124,278	26,086	100,540	1,032	10,436	299,418	1,696,322
1912..	278,276	1,629,105	5.85	23,112	184,018	32,473	127,004	794	12,109	334,655	1,952,236
1913..	268,666	1,623,993	6.04	24,986	204,911	42,582	155,693	1,889	22,178	338,123	2,006,775
1914..	328,038	1,927,425	5.88	16,761	122,325	50,099	195,956	3,232	41,712	398,100	2,287,418
1915..	209,132	1,152,778	5.51	8,864	62,589	23,718	90,367	1,343	12,433	243,057	1,318,147
1916..	253,707	1,326,684	5.22	2,501	12,134	42,478	163,421	180	1,994	298,866	1,504,233
1917..	241,029	1,315,769	5.46	88	709	26,581	123,439	338	2,142	268,036	1,442,059
1918..	168,100	1,153,240	6.86	114	983	26,984	163,484	137	1,087	195,335	1,318,794

The imports of clay, though not large, are nevertheless essential under present conditions to some industries. This is especially true of the white ware, porcelain, sanitary ware, paper, paint, and oilcloth industries, which use large quantities of imported kaolin or china clay. Prior to 1914 comparatively large and increasing quantities of high-grade plastic fire clay were imported from Germany for use in the manufacture of crucibles, glasspots, abrasives, pencil leads, and enameled ware. Some of the English clays have also been used for these purposes, but by far the larger part of the clay for these uses came from Germany. In the absence of these clays domestic substitutes have been sought and found more or less successfully. The consensus of opinion of the users seems to be, however, that the domestic clay as marketed is not so satisfactory as the imported. Many hold that with proper preparation and blending satisfactory clays will be developed in the United States. In addition to the kaolin and fire clay imported from England, much, if not all, of the so-called "unwrought" clay was English ball clay used principally in high-grade pottery. Imports of all of these clays have decreased during the last few years, those from Germany, of course, ceasing entirely. The prices per ton also seem low. But these prices are at the port of shipment and when the cost of freight and other expenses are added the price delivered at the point of consumption is often more than double.

In view of the prevailing conditions in 1918 a decrease in imports of clay, which come almost entirely from Europe, was to be expected. To add to the difficulties the British shipping authorities in the summer of 1918 ruled that no exports of clay would be permitted from England to Boston, New York, or Philadelphia. The object of this order was to prevent congestion in these ports and to make the ships available for more important cargoes. As nearly all clay imports in 1918 came from England, and as these ports were the principal ones to which clay is normally shipped, the effect of the order must have tended to reduce imports. As a matter of fact, clay imported and entered for consumption did decrease 72,701 tons, or

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27 per cent, compared with 1917. The value of the imported clay also decreased, but not in so great proportion. This decrease was $123,265, or 9 per cent. For many years the chief clay imported has been kaolin or china clay. In 1918 it constituted 86 per cent of the quantity and 87 per cent of the value of the imported clay. The imports of kaolin decreased 72,929 tons, or 30 per cent, and were only about one-half as great as they were in 1914, the year of maximum imports. The value of imported kaolin decreased $162,529, or 12 per cent. Compared with 1914, the decrease in value was $774,185, or 40 per cent. The average price per ton of kaolin at the port of shipment in 1918 was $6.86, an increase of $1.40. When, however, freight, insurance, duty, etc., are added the price to the consumer is very much greater than the figures given. In fact, quotations given in New York trade journals for imported china clay ranged from $17.50 to $40 per ton in 1918, compared with $15 to $32 in 1917, $11 to $16 in 1916, and $14 to $16 in 1914 and 1915. It is interesting to know uses to which imported kaolin are put and the following estimates by uses have been made: Paper, 60 per cent; pottery, 25 per cent; paint, 3 per cent; tile, 2 per cent; oilcloth, 4 per cent; and miscellaneous uses, 6 per cent. Clays imported under the name of common blue and Gross-Almerode glasspot clays came principally from Germany, and hence have declined from 24,986 tons in 1913 to nothing in 1918, the negligible quantities reported for 1917 and 1918 probably coming from England.

Unwrought clay, which is believed to be principally English ball clay, increased slightly in quantity—403 tons—but increased $40,045, or 32 per cent, in value.

EXPORTS.

Exports of clay have been reported separately only for a few years. Fire clay is the chief kind exported. In 1918 it constituted 71 per cent of the quantity exported and 63 per cent of its value.

Clay exported from the United States, 1916–1918.

Year.	Fire clay.		All other.		Total.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
1916	45,752	$144,552	27,941	$145,970	73,693	$290,522
1917	54,023	268,093	29,194	178,764	83,217	446,857
1918	60,206	333,880	24,348	192,053	84,554	525,933

SILICA BRICK.

PRODUCTION.

The production of silica fire brick has made wonderful progress in the last nine years, as is shown in the following table:

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Silica brick produced in the United States, 1910–1918.

Year.	Quantity (thousands).	Value.	Average price per thousand.
1910	145,779	$3,289,028	$22.56
1911	104,483	2,520,816	24.13
1912	135,578	2,923,174	21.56
1913	174,246	3,815,806	21.90
1914	129,693	2,951,525	22.76
1915	130,244	3,039,869	23.34
1916	232,673	6,369,256	27.37
1917	327,030	15,510,595	47.43
1918	336,562	19,987,803	59.39

In 1918 silica brick was produced in 13 States, an increase of 2 compared with 1917. Maryland, New Jersey, and Washington, which reported no silica brick in 1917, entered the list of producers in 1918 and Kentucky reported none. The States reporting silica brick for 1918 were: Alabama, California, Colorado, Illinois, Indiana, Maryland, Missouri, Montana, New Jersey, Ohio, Pennsylvania, Utah, and Washington. As there were three producers or more in only two States, Ohio and Pennsylvania, totals for these States only can be given. Pennsylvania was the leading State in 1918, as it had been throughout the period covered by the table, and it reported 233,143,000 9-inch equivalent brick, valued at $13,352,687, or 69 per cent of the total output and 67 per cent of the total value. The output in Pennsylvania increased 10,100,000 brick, or nearly 5 per cent, and the value increased $2,933,142, or 28 per cent, compared with 1917. Illinois was second and Indiana third in rank. These three States reported 91 per cent of the total output and value in 1918. Ohio was fourth with an output of 7,161,000 brick, valued at $386,179.

The output increased during this period from a minimum of 104,483,000 brick, valued at $2,520,816, in 1911 to 336,562,000 brick, valued at $19,987,803, in 1918, an increase of 232,079,000 brick, or 222 per cent, in quantity, and of $17,466,987, or 693 per cent, in value. The increase in 1918 compared with 1917 was 9,532,000 brick, or 3 per cent, in quantity, and $4,477,208, or 29 per cent, in value. The rapid rise in the output and value of this material, especially in the last few years, may be ascribed to the war, which increased the demand for iron and steel and coke-oven by-products, in the making of which silica refractory brick finds its chief use.

The Bureau of Standards, of the Department of Commerce, has recently issued a very comprehensive report[1] on this subject, from which the following extracts are taken:

The following remarks describe the general method of manufacture at a plant which uses Pennsylvania Medina quartzite. Most other silica-brick plants in the United States follow approximately this procedure except as noted below.

The rock direct from the quarry is crushed to pass through a 2-inch ring. Washing of the rock to remove foreign or earthy matter may be resorted to at certain places. The material is then taken in a car to the wet pan and there dumped. Each charge for a pan weighs about 1,250 pounds. A little water is added and the material is ground for 15 minutes. After 10 minutes of this grinding, 2 per cent of lime by weight is added as slaked high-calcium lime, in the form of a thin slip. It is run through a

[1] Ross, D. W., Silica refractories: Bur. Standards Tech. Paper 116, 1919.

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spout to the middle of the crushing surface of the pan, while the pan is in motion. * * *. In this way the lime is thoroughly mixed with the quartzite. When the grinding has continued for the full 15 minutes the mix is ready for molding and is removed from the pan to a tramcar by means of a mechanical scraper.

The lime is prepared by weighing out enough quicklime to furnish exactly 2 per cent of CaO to the weight of quartzite. The weighing out is done on the basis of an analysis. Thus, if the lime contains only 90 per cent CaO, proportionately more is added. This lime is then placed in a small mixer or blunger; is slaked and stirred up to the proper consistency; and then run through a screen of approximately 10 meshes per linear inch on its way to the wet pan. Hydrated lime is sometimes weighed into the mixer instead of quicklime and appears to give exactly the same results.

From the pan the mix is carried to an elevator, raised to an upper floor, and dropped into a container, from which the workmen use it directly in filling the brick molds. This container is in the nature of a cylinder approximately 5 feet in diameter and 10 to 15 feet tall, with slatted openings at the bottom, so that the material can be removed readily. The slats can also be removed. The molders work at benches adjoining the outlets of the containers. The brick molds are of iron and consist of a bottom plate on which lies a 3-brick form. The brand on the brick is formed by the bottom plate of the mold. Directly above the molds is situated a screen, which can be shaken by the operator. Pennsylvania washed glass sand is placed upon this screen, and a slight jar is sufficient to shake down enough sand to sand a set of molds.

* * * A mass of mix is wadded together with the hands and is then thrown heavily into the molds and rammed in, the surplus struck off, and the bricks turned out on an iron pallet. These pallets are then placed on drier cars. When a car is full it is left standing in the open for a few minutes and is then run into a hot-air drier. Regular burn brick are made up just wet enough so that they will fill the corners of the molds readily. The mix for large shapes is made slightly drier than for regular brick, but the grind is longer, approximately two or three pans per hour instead of four. (The grind for regular brick is at the rate of four pans per hour.) This extra grinding aids in producing a more plastic consistency. The material for large shapes is pounded into the molds with heavy wooden mallets. As the jars due to the plant engines and passing trains tend to cause large shapes to deform before they get their initial set, the stiffer they are when they come from the mold, the better.

Of course the time of grinding at each plant will depend somewhat upon the nature of the quartzite used and the ware being turned out. Some plants make up brick as described above, and when the bricks are partially dry they are re-pressed. Another way is to have the mix somewhat drier to start with and make the brick up directly on a dry press machine.

Practically all types of driers used for drying heavy clay wares have also been applied to drying silica wares. Perhaps the most satisfactory type from an economical standpoint is a Richardson type tunnel drier, using waste heat from cooling kilns, and if necessary an auxiliary heater, either a small furnace and brick checkerwork, or else by passing air over exhaust steam pipes. Silica brick give practically no trouble in drying. The only requirement is that the brick must be bone dry before being set in the kilns. Otherwise, they break under the pressure when set, or tend to slump and break during water smoking.

* * * The kilns are of the regulation circular down-draft type, varying from 30 to 40 feet in diameter. The bag walls are usually low, as direct fire does not appear to affect the brick much. Regular 9-inch silica brick are set approximately 3 to 3½ on 1, or, in other words, ½ inch is left between the bricks to allow for expansion. They are put in benches 4 feet wide by the width of the kiln by the height of the kiln, and a space of 4 inches is left between benches, and approximately 18 inches between the top of the bench and the crown of the kiln. This latter is done to prevent lifting of the crown of the kiln by the expanding brick. Thus, the benches are from 12 to 15 feet high. As set in the kilns there is a pressure of approximately 15 pounds per square inch on the bottom brick, which do not crush or crack if they are thoroughly dry. A course of bats is put in occasionally to level up the bench horizontally, but they are not used in any way to take the load off the unburned brick. In general the time of burning is nine days, with a maximum heat treatment equivalent to cone 14–18. Five to eight additional days are required for cooling.

A departure from the usual method of burning, which is used by some plants, is the continuous-tunnel kiln. With these kilns the period of burning is approximately a week, and the cooling takes another week. The maximum heat treatment is equivalent to cone 12–14.

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In England and other European countries brick which contain 96 per cent or more of SiO_2 are manufactured in a manner similar to that used for making silica brick in the United States, except that the methods of mixing, etc., vary somewhat. It is a frequent custom in England to use a somewhat lower percentage of lime (1.3 per cent or even less) and add a small precentage of a highly siliceous clay to strengthen the brick in the raw state. If clay were not added to these brick, they would be weak because of their low lime content.

In England segmental gas retorts are frequently made from materials which contain 85 to 92 per cent of SiO_2. Such pieces are, of course, made by mixing larger percentages of siliceous clays with the silica, and hence do not correspond to silica brick as manufactured in the United States.

USES IN INDUSTRIES.

Silica refractories are particularly useful in industrial work. This is due to their rigidity at temperatures above the range of usefulness of ordinary fire-clay brick and to the fact that they expand slightly when heated instead of shrinking as clay brick do.

For by-product coke-oven work the brick in the regenerative and lower two-thirds of the coking chamber should have a high fusion point, as an extreme temperature of 1,510 to 1,540° C. is sometimes reached. The brick in the lower two-thirds of the coking chamber, where they come in contact with the coal and coke during charging and unloading, must also resist abrasion. The upper one-third of the coking chamber may be made of lower fusion point material and need not be particularly resistant to abrasion, as here the temperature rarely exceeds 1,320° C. and the brick are seldom touched by coal or coke. Occasionally charges of coal have been found to expand in the coking chambers, so that when coked they could not be removed by the usual mechanical device. Trouble from cracking and spalling may sometimes occur if the ovens are heated up too rapidly. However, when the temperature of a series of these ovens is once raised to the operating temperature, they should last for years, except for repairs occasioned by abrasion, etc.

From the work of Blasberg [1] we gather that silica refractories which have been used in Siemens by-product coke ovens frequently show an increase in iron and always a considerable increase in alkalies, particularly the brick used in the checkerwork. In many cases they contain up to 1 per cent of carbon. It is assumed that the carbon comes from the dissociation of gaseous hydrocarbons or carbon monoxide, and that the other contamination comes from the coal ash. The conclusions drawn are that for this work silica brick should be as low in porosity as possible and that the gases should be free from flue dust.

In open-hearth steel furnace work, silica brick are used for the top, ends, and sometimes for the side walls of the furnace. Here the chief essentials are that the brick have a high crushing strength when hot and high resistance to spalling and slagging, as well as high softening temperature.

The port bulkheads at the ends of these furnaces are subjected to a severe sand-blast action from particles of limestone and iron oxide, which are blown over from the hearth of the furnace. As these materials both act as active fluxes on silica brick under reducing conditions, the result is that these bulkheads are rapidly eaten away by a combined cutting and slagging action. The 13-inch brick used in these bulkheads wear away so fast that it is frequently necessary to replace them in two or three weeks. Crowns of such furnaces are also somewhat attacked by the slagging action of lime and iron oxide which are blown up against them and also by the dust of the gaseous fuel used. Thus, an average crown lasts approximately 300 heats when natural gas, which is quite free from dust, is used as a fuel; approximately 200 heats with producer gas, which contains considerable dust; and somewhat less than 200 heats when powdered coal is used.

For steel furnace work it is desirable that the softening temperature (as described below) of the brick be somewhat above that of Orton cone No. 31. Even then, at times the surface of the bricks will melt and hang down in long white stalactite-like forms from the crown of a furnace.

The uses of silica refractories in copper reverberatory furnaces are similar to those in open-hearth steel furnaces, except that for melts of lead-free metallic copper, silica can be used throughout the furnace except at the slag line. For this work the brick should be as low in porosity as possible to avoid absorption of copper oxide, which slags away the bricks when the furnace is at its maximum temperature. Silica brick arches in copper furnace work wear much better if they are not insulated.

[1] Stahl u. Eisen, vol. 30, pp. 1055-1060; 1910.

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The maximum temperature reached in the copper refining furnaces is approximately 1,350° C.; hence, for this purpose some refractoriness might be sacrificed if anything is to be gained thereby in decreased porosity and resistance to spalling.

In glass furnace work silica refractories are used for furnace roofs, and are useful for stiffening up walls, etc., made of clay brick, which would otherwise soften and sag from the effect of heat and fumes arising from the glass.

BUILDING OPERATIONS.

The accompanying tables show the building operations in 1918 in some of the larger cities of the country as indicated by reports obtained from their building departments. Efforts were made to obtain detailed information from 150 cities. Sufficient detail was received from 132 to permit their inclusion in a table showing classes of buildings, but 11 reported only the total number of permits or buildings and the cost of the buildings, and 7 furnished no data.

Statistics of building operations have been collected by the United States Geological Survey only from cities that had a population of 35,000 or more at the last Federal census; none were obtained from the smaller cities or rural communities, from which, so far as known, no effort has ever been made to collect such statistics, as the absence of building regulations in them makes it impracticable.

The table on page 929 makes a comparison between 1917 and 1918 for 58 cities, Greater New York being considered one city. The figures show, as was to be expected, that in most of the cities there was a large decrease in the number and cost of buildings in 1918 compared even with 1917, which showed a large decrease from 1916. The decrease in these cities in 1918 compared with 1916 was $557,647,911, or 61 per cent, and when it is remembered that higher prices increased the cost of the operations in 1918 as compared with the cost of those of 1917 these decreases assume added significance.

The outlook for 1919, notwithstanding the high cost of material and labor, appears to be good, not only because buildings of all kinds are imperatively needed but because it is realized that there is no prospect that costs will be lowered; further, the reports received indicate that building operations throughout the country are rapidly assuming normal proportions and that not only cost will be much greater in 1919 than in 1918, but that the number of operations will also show a large increase. The building industry now has a double opportunity—it may be able to relieve unemployment and at the same time to provide homes, shops, factories, and offices that are in many places sorely needed.

Of the 58 cities given in the first table 48 showed decrease and 10 showed increase in the total cost of building operations. Only one of the cities included in this table—Youngstown—showed increase in both 1917 and 1918. Nine of the cities that increased in 1917 decreased in 1918—Akron, Ohio; Atlanta, Ga.; Denver, Colo.; El Paso, Tex.; Hartford, Conn.; Los Angeles, Calif.; New Haven, Conn.; Sioux City, Iowa; and Waterbury, Conn.; and nine cities that decreased in 1917 increased in 1918—Camden, N. J.; Des Moines, Iowa; Jersey City, N. J.; Louisville, Ky.; Oakland, Calif.; Portland, Oreg.; Providence, R. I.; St. Paul, Minn.; and Seattle, Wash. Thirty-nine cities showed decrease in both years. Two cities—Chester, Pa., and Omaha, Nebr.—have not reported for 1918, and they are therefore not included in the table.

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The largest decrease was in Greater New York. The next four cities, Chicago, Detroit, Cleveland, and Philadelphia, also showed large decreases.

Various reasons are given for these changes. The dominant reasons for the decreases are the restriction of the use of building materials by the Government to necessary war work and the scarcity and high cost of materials and labor. The causes for the increases are the excessive cost, due to the high price of labor and materials, and the increase in operations in the centers of Government building activities, such as Camden, N. J., Portland, Oreg., Providence, R. I., and Seattle, Wash. The construction and occupation of the army camps and cantonments probably had a stimulating effect on the building industries in the neighboring cities, although Des Moines, Iowa, near which Camp Dodge was located, reported that the increase in that city was due chiefly to the erection of two large hotels and a municipal courthouse. It is quite conceivable, however, that the demand for the hotels was caused, to some extent at least, by the proximity of the camp.

The cost of building operations in these cities in 1918 ranged from $469,423 in Newton, Mass., to $53,602,004, in Greater New York, and the average for these 58 cities was $6,099,183, compared with $10,104,531, in 1917, and $15,713,802, in 1916. The number of permits issued or buildings erected in 1918 in these cities was 46,208 less than in 1917, and 117,546 less than in 1916.

In addition to the general building operations, vast building operations were carried on by the United States Government in 1917 and 1918, principally in army cantonments and camps and navy yards and docks. The United States Housing Corporation erected buildings in 28 cities. The Government, through the office of the Supervising Architect, carried on building operations in 27 cities; the Emergency Fleet Corporation erected houses at a number of places for the accommodation of its employees; the Navy Department conducted building operations in 41 places. In the aggregate they involved a very large expenditure of material and money. Complete information concerning all these expenditures is not yet available.

It has been impracticable to report the expenditures by the Construction Division of the War Department either by calendar years or by character of construction. The allotments for the fiscal year 1918 for construction work of all kinds for the Army, including public utilities, was $420,259,162. This work included 16 National Army camps, 16 National Guard camps (in which 43,234 buildings were constructed), embarkation camps, camps for artillery, Engineer Corps, Motor Transport Corps, work on coast defenses, Quartermaster Army supply bases, depots, and warehouses, hospitals, ordnance depots, proving grounds, and regular Army posts. In March, 1918, at the time of the reorganization of the Construction Division, emergency work costing $600,000,000 was in prospect for munitions factories, storage warehouses, hospitals, port terminals, and interior depots in all parts of the country.[1] Some of this was covered by the $420,259,162 already mentioned. In addition, during the first half of the fiscal year 1919 (July 1 to December 31, 1918) many more millions of dollars was spent by the War Department in the construction of buildings at camps and elsewhere, so that it seems safe to

[1] Report of the Chief of the Construction Division to the Secretary of War, 1918, p. 33.

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estimate that from July 1, 1917, to the end of 1918 the sum of $1,000,000,000 was spent by the War Department for structural work. If to this sum is added the cost of other Government work in 1918—$102,960,977—it will be seen that after allotting a large proportion of the expenditures of the War Department to non-structural work the cost of building operations of the Government largely offset the loss in general building operations.

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Building operations in the leading cities of the United States in 1917 and 1918.

City.	1917		1918		Increase or decrease 1918.	
	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	Cost.	Percentage.
Akron, Ohio	5,039	$14,166,818	2,185	$4,112,236	−$10,054,582	− 71.0
Atlanta, Ga	2,274	4,967,676	2,044	3,572,086	− 1,395,590	− 28.1
Baltimore, Md	1,424	6,299,643	6,170	5,390,483	− 909,160	− 14.4
Boston, Mass	4,679	23,294,161	3,977	7,704,190	− 15,589,971	− 66.9
Bridgeport, Conn	1,491	4,497,983	982	3,040,913	− 1,457,070	− 32.4
Buffalo, N. Y	4,068	10,501,000	3,457	7,014,000	− 3,487,000	− 33.2
Cambridge, Mass	561	3,146,367	454	2,170,368	− 975,999	− 31.0
Camden, N. J	794	2,305,483	481	7,727,187	+ 5,421,704	+235.2
Canton, Ohio	970	2,647,280	917	1,845,067	− 802,213	− 30.3
Chicago, Ill	4,838	49,167,990	2,529	34,792,200	− 14,375,790	− 29.2
Cincinnati, Ohio	4,262	9,151,925	3,200	4,265,635	− 4,886,290	− 53.4
Cleveland, Ohio	11,952	30,483,750	8,668	16,385,800	− 14,097,950	− 46.2
Columbus, Ohio	2,117	3,915,030	1,824	3,301,220	− 613,810	− 15.7
Dallas, Tex	814	3,577,849	537	1,668,030	− 1,909,819	− 53.4
Denver, Colo	2,357	4,252,000	1,960	2,595,890	− 1,656,110	− 38.9
Des Moines, Iowa	982	2,640,469	670	4,460,566	+ 1,820,097	+ 68.9
Detroit, Mich	12,109	39,666,800	7,010	18,226,832	− 21,439,968	− 54.1
Duluth, Minn	1,460	4,508,665	1,243	2,627,814	− 1,880,851	− 41.7
El Paso, Tex	1,474	3,749,407	1,041	626,121	− 3,123,286	− 83.3
Flint, Mich	1,453	2,454,805	670	945,453	− 1,509,352	− 61.5
Fort Wayne, Ind	569	3,329,091	329	913,124	− 2,415,967	− 72.6
Grand Rapids, Mich	1,351	1,817,165	858	1,199,985	− 617,180	− 34.0
Hartford, Conn	1,082	7,671,616	808	2,978,561	− 4,693,055	− 61.2
Houston, Tex	2,423	2,644,468	2,206	2,270,649	− 373,819	− 14.1
Indianapolis, Ind	5,086	7,103,102	4,308	4,558,676	− 2,544,426	− 35.8
Jersey City, N. J	364	2,628,283	684	4,232,693	+ 1,604,410	+ 61.0
Kansas City, Mo	3,259	10,128,450	1,910	5,649,645	− 4,478,805	− 44.2
Los Angeles, Calif	6,699	16,932,082	6,381	8,678,862	− 8,253,220	− 48.7
Louisville, Ky	1,287	1,758,060	1,213	2,017,432	+ 259,372	+ 15.0
Memphis, Tenn	1,694	2,626,855	643	1,591,078	− 1,035,777	− 39.4
Milwaukee, Wis	14,983	11,270,292	11,043	6,513,096	− 4,757,196	− 42.2
Minneapolis, Minn	4,992	9,258,365	3,695	5,395,740	− 3,862,625	− 41.7
Nashville, Tenn	1,615	1,036,676	1,211	534,783	− 501,893	− 48.4
Newark, N. J	2,488	9,395,920	1,696	5,336,033	− 4,059,887	− 43.2
New Bedford, Mass	384	3,054,161	352	976,714	− 2,077,447	− 68.0
New Haven, Conn	1,230	5,642,869	928	3,227,058	− 2,415,811	− 42.8
New Orleans, La	823	2,814,051	542	1,770,930	− 1,043,121	− 37.1
Newton, Mass	654	1,756,586	352	469,423	− 1,287,163	− 73.3
New York, N. Y.:						
Bronx	3,037	10,126,360	1,847	5,207,320	− 4,919,040	− 48.6
Brooklyn	12,255	33,590,071	4,824	21,566,382	− 12,023,689	− 35.8
Manhattan	3,756	42,738,169	2,668	17,697,650	− 25,040,519	− 58.6
Queens	7,018	13,285,210	2,228	6,768,138	− 6,517,072	− 49.1
Richmond	1,643	3,766,757	1,308	2,362,514	− 1,404,243	− 37.3
	27,709	103,506,567	12,875	53,602,004	− 49,904,563	− 48.2
Oakland, Calif	2,938	4,442,520	2,948	5,382,160	+ 939,640	+ 21.2
Peoria, Ill	718	4,183,574	532	1,941,163	− 2,242,411	− 53.6
Philadelphia, Pa	7,555	33,050,220	5,820	15,340,500	− 17,709,720	− 53.6
Pittsburgh, Pa	3,587	11,318,502	2,571	7,938,350	− 3,380,152	− 29.9
Portland, Oreg	3,377	3,643,410	5,707	6,176,047	+ 2,532,637	+ 69.5
Providence, R. I	2,881	3,817,800	2,532	4,963,100	+ 1,145,300	+ 30.0
Richmond, Va	1,558	4,118,688	949	1,838,614	− 2,280,074	− 55.4
Rochester, N. Y	2,268	6,739,620	1,361	1,949,551	− 4,790,069	− 71.1
St. Louis, Mo	7,491	12,538,532	5,396	6,352,582	− 6,185,950	− 49.3
St. Paul, Minn	2,794	7,266,706	1,977	10,152,709	+ 2,886,003	+ 39.7
San Francisco, Calif	5,513	15,635,319	3,688	7,924,319	− 7,711,000	− 49.3
Seattle, Wash	7,736	6,714,315	12,016	10,876,183	+ 4,161,868	+ 62.0
Sioux City, Iowa	582	3,328,206	416	3,097,209	− 230,997	− 6.9
Springfield, Mass	1,199	3,779,612	787	1,598,423	− 2,181,189	− 57.7
Toledo, Ohio	3,156	7,264,546	1,529	2,660,161	− 4,604,385	− 63.4
Washington, D. C	3,141	12,507,311	4,362	10,675,632	− 1,831,679	− 14.6
Waterbury, Conn	1,394	6,562,930	1,251	3,852,620	− 2,710,310	− 41.3
Worcester, Mass	1,705	4,838,840	1,195	2,066,734	− 2,772,106	− 57.3
Youngstown, Ohio	1,641	4,542,395	1,726	4,577,984	+ 35,589	+ .8
	205,024	586,062,806	158,816	353,752,618	−232,310,188	− 39.6

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Building statistics of the leading cities of the United States in 1918.

City.	Wooden buildings.						Fire-resisting buildings.			
	New.		Additions, alterations, and repairs.		Total.		Brick or hollow tile.			
							New.		Additions, alterations, and repairs.	
	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.
Akron, Ohio	1,383	$1,981,671	454	$186,415	1,837	$2,168,086	235	$1,576,180	112	$367,970
Albany, N. Y	27	181,600	1,032	396,745	1,059	578,445	83	437,545	455	270,236
Allentown, Pa	35	11,680	35	11,175	70	22,855	54	494,100	73	129,760
Altoona, Pa	159	71,900	124	48,986	283	120,886	18	21,780	.....	.....
Atlanta, Ga	311	1,353,988	948	570,422	1,259	1,924,410	65	1,162,709	.....	.....
Atlantic City, N. J	28	30,275	a 338	a 429,780	366	460,005	31	70,506	.....	.....
Augusta, Ga	34	78,715	955	126,814	989	205,529	25	151,628	64	59,432
Baltimore, Md	52	162,400	977	227,520	1,029	389,920	613	3,295,030	3,928	1,516,221
Bayonne, N. J	29	119,000	69	46,480	98	165,480	11	81,400	12	25,785
Berkeley, Calif	100	255,000	500	205,700	600	460,700	5	56,500	.....	.....
Binghamton, N. Y	574	149,403	a 900	a 175,095	1,474	324,498	50	282,795	.....	.....
Birmingham, Ala	497	400,141	2,223	294,396	2,720	694,537	30	528,507	235	167,483
Boston, Mass	287	407,107	2,313	706,300	2,600	1,113,407	113	1,956,580	1,085	2,532,577
Bridgeport, Conn	562	787,330	191	102,373	753	889,703	132	1,751,430	48	362,990
Brockton, Mass	121	96,580	118	124,213	239	220,803	2	33,000	4	20,000
Buffalo, N. Y	2,406	3,066,000	753	876,000	3,159	3,962,000	204	2,046,000	27	150,000
Butte, Mont	195	306,354	248	101,578	443	407,932	27	98,600	21	17,585
Cambridge, Mass	71	739,489	193	120,203	264	859,692	17	160,800	112	445,866
Camden, N. J	81	164,822	75	24,892	156	189,714	143	7,121,451	150	156,452
Canton, Ohio	439	1,212,250	84	54,910	523	1,267,160	52	228,820	16	57,100
Charleston, S. C	121	219,658	70	20,228	191	239,886	15	207,005	27	44,375
Chattanooga, Tenn	19	82,500	916	112,570	935	195,070	23	138,200	30	56,280
Cincinnati, Ohio	604	389,720	1,182	474,470	1,786	864,190	141	1,078,180	1,213	946,265
Cleveland, Ohio	6,290	5,574,560	1,438	586,640	7,728	6,161,200	413	5,478,175	390	1,087,325
Columbus, Ohio	844	674,775	403	111,945	1,247	786,720	134	1,028,635	331	946,180
Covington, Ky	22	22,050	32	20,600	54	42,650	27	55,200	35	38,350
Dallas, Tex	149	348,208	309	312,897	458	661,105	59	636,050	20	370,875
Dayton, Ohio	837	1,638,820	248	105,750	1,085	1,744,570	75	1,092,620	35	116,160
Denver, Colo	11	9,600	.....	.....	11	9,600	881	1,914,840	921	646,950
Des Moines, Iowa	515	908,278	32	36,875	550	945,153	80	1,072,453	18	71,310
Detroit, Mich	3,627	3,975,857	2,366	921,400	5,993	4,897,317	400	4,323,605	443	1,947,805
Dubuque, Iowa	50	63,575	1	200	51	63,775	7	31,400	.....	.....

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Duluth, Minn	591	1,101,069	542	478,924	1,133	1,579,983	24	576,315	83	281,516
East St. Louis, Ill	68	113,090	32	33,755	100	146,845	58	657,531	9	50,590
Elizabeth, N. J	184	426,031	46	29,916	230	455,947	18	850,800	20	91,194
Elmira, N. Y	65	151,350	.....	.....	65	151,350	4	36,500	.....	.....
El Paso, Tex	.....	.....	232	51,725	232	51,725	204	321,410	432	116,710
Erie, Pa	584	1,105,367	[a] 447	[a] 543,394	1,031	1,648,761	114	499,322	.....	.....
Evansville, Ind	135	82,402	405	69,284	540	151,686	22	150,075	18	36,600
Fall River, Mass	99	136,970	115	52,375	214	189,345	21	121,030	10	88,850
Fitchburg, Mass	72	76,624	68	47,482	140	124,106	6	42,750	8	23,400
Flint, Mich	365	416,748	252	153,845	617	570,593	12	69,600	25	27,300
Fort Wayne, Ind	144	250,225	107	79,208	251	329,433	37	453,616	35	123,425
Fort Worth, Tex	243	413,931	203	124,781	446	538,712	80	682,455	86	299,155
Galveston, Tex	32	42,044	44	2,047	76	44,091	2	2,550	102	4,198
Grand Rapids, Mich	341	204,906	359	112,221	700	317,127	41	571,289	73	239,694
Harrisburg, Pa	53	22,890	24	15,950	77	38,840	63	661,725	64	103,790
Hartford, Conn	313	394,902	353	621,459	666	1,016,361	90	1,502,575	52	399,625
Hoboken, N. J	24	37,844	59	32,224	83	70,078	15	180,497	61	58,010
Holyoke, Mass	31	84,575	21	12,620	52	97,195	14	47,425	28	63,650
Houston, Tex	478	1,014,554	1,338	319,462	1,816	1,334,016	31	246,331	267	139,219
Indianapolis, Ind	1,130	1,403,170	2,062	629,928	3,192	2,033,098	68	592,112	426	232,480
Jacksonville, Fla	138	480,590	182	128,480	320	609,070	20	238,750	107	189,707
Kalamazoo, Mich	37	98,310	25	17,610	62	115,920	2	6,000	2	3,500
Kansas City, Kans	63	83,600	162	179,441	225	263,041	24	182,275	.....	.....
Kansas City, Mo	743	782,340	570	282,445	1,313	1,064,785	67	906,100	261	669,125
Knoxville, Tenn	69	383,036	640	93,424	709	476,460	10	83,500	66	83,385
Lancaster, Pa	.....	.....	.....	.....	.....	.....	53	170,615	106	112,025
Lawrence, Mass	44	143,690	77	60,100	121	203,790	12	1,355,468	27	216,650
Lincoln, Nebr	199	323,701	74	60,450	273	384,151	26	231,700	39	134,321
Little Rock, Ark	292	416,840	192	124,116	484	540,956	81	101,235	74	57,521
Los Angeles, Calif	2,047	4,800,823	1,671	885,478	3,718	5,686,306	81	833,049	[b] 1,250	[b] 926,752
Louisville, Ky	371	350,078	399	122,368	770	472,446	165	1,174,618	278	370,368
Lowell, Mass	186	461,703	293	364,864	479	826,567	32	403,470	39	112,325
Lynn, Mass	123	51,203	114	63,060	237	114,263	3	5,600	16	216,347
McKeesport, Pa	74	111,412	61	28,662	135	140,074	28	121,215	7	6,810
Macon, Ga	51	122,474	479	215,575	530	338,049	15	112,831	6	19,200
Malden, Mass	54	24,000	155	132,000	209	156,000	2	84,000	20	122,420
Manchester, N. H	180	116,920	349	133,607	529	250,527	5	16,500	26	46,935
Milwaukee, Wis	1,011	1,791,002	1,104	1,010,864	2,115	2,801,866	148	816,957	.....	.....
Minneapolis, Minn	1,420	1,941,485	1,670	673,745	3,090	2,615,230	95	1,058,675	312	402,195
Mobile, Ala	32	24,275	12	6,684	44	31,659	3	29,500	6	19,625
Nashville, Tenn	37	65,465	604	67,572	641	133,037	21	103,450	548	294,769
Newark, N. J	274	786,099	[c] 836	[c] 1,123,459	1,110	1,909,558	462	3,410,736	(c)	(c)
New Bedford, Mass	109	268,525	127	255,164	236	523,689	.....	.....	116	453,025
New Haven, Conn	184	441,860	346	189,914	530	631,774	[d] 104	[d] 2,344,632	92	191,271
New Orleans, La	294	684,733	167	125,776	461	810,509	36	759,073	40	136,348
New York:										
Brooklyn	621	2,063,368	884	838,969	1,505	2,902,337	2,110	15,513,237	1,125	2,868,988
Bronx	31	135,450	124	157,465	155	292,915	166	3,271,300	156	714,785
Manhattan	9	58,500	35	64,850	44	123,350	127	3,071,950	2,076	7,087,232
Queens	800	2,082,167	.....	.....	800	2,082,167	1,141	4,416,828	.....	.....
Richmond	494	867,421	262	112,496	756	979,917	113	975,992	104	315,521

For footnotes see p. 941.

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Building statistics of the leading cities of the United States in 1918—Continued.

City.	Wooden buildings.						Fire-resisting buildings.			
	New.		Additions, alterations, and repairs.		Total.		Brick or hollow tile.			
							New.		Additions, alterations, and repairs.	
	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.
Norfolk, Va	282	$1,109,605	49	$43,569	331	$1,153,174	84	$883,093	45	$401,380
Oakland, Calif	1,502	3,298,801	1,367	701,995	2,869	4,000,796	40	751,327	10	52,745
Oklahoma, Okla	445	1,869,450	186	155,546	631	2,024,996	10	330,500	4	112,500
Passaic, N. J	76	63,070	72	71,375	148	134,445	17	229,350	16	26,725
Paterson, N. J	121	208,756	475	154,072	596	362,828	74	488,515	66	110,154
Pawtucket, R. I	41	137,350	74	34,615	115	171,965	18	355,000	.....	.....
Philadelphia, Pa	11	36,500	40	8,625	51	45,125	1,546	7,377,065	4,050	6,014,065
Portland, Me	126	162,898	111	95,157	237	258,055	17	110,997	49	232,595
Portland, Oreg	2,962	2,598,312	2,065	638,865	5,027	3,237,177	37	372,895	441	314,040
Providence, R. I	476	779,800	1,715	668,700	2,191	1,448,500	55	2,538,300	154	314,500
Pueblo, Colo	93	116,097	101	35,720	194	151,817	21	140,900	156	33,790
Quincy, Ill	5	16,300	.....	.....	5	16,300	5	46,400	3	21,000
Reading, Pa	.....	.....	103	7,500	103	7,500	42	135,125	1,045	252,375
Richmond, Va	22	177,950	271	83,487	293	261,437	161	919,769	405	619,255
Rochester, N. Y	613	538,567	455	183,702	1,068	722,269	38	507,425	123	305,502
Sacramento, Calif	50	221,470	416	133,981	466	355,451	17	238,868	155	143,610
Saginaw, Mich	253	240,326	147	69,721	400	310,047	26	165,900	.....	.....
St. Joseph, Mo	43	79,195	165	40,797	208	119,992	32	134,925	68	50,755
St. Louis, Mo	1,552	257,821	1,592	289,029	3,144	546,850	462	3,823,774	1,790	1,981,958
St. Paul, Minn	692	1,421,573	258	347,851	950	1,769,424	110	1,063,062	64	154,595
Salem, Mass	43	52,775	306	104,221	349	156,996	1	7,000	2	13,200
Salt Lake City, Utah	99	56,785	70	43,305	169	100,090	349	1,970,360	203	249,245
San Antonio, Tex	955	1,523,500	783	187,756	1,738	1,711,256	91	483,455	.....	.....
San Diego, Calif	364	877,314	427	186,921	791	1,064,235	32	285,825	221	168,499
San Francisco, Calif	442	1,561,973	2,770	800,200	3,212	2,362,173	96	1,900,000	152	570,000
Savannah, Ga	68	121,000	39	42,625	107	163,625	9	542,800	18	33,400
Schenectady, N. Y	306	390,219	232	70,552	538	460,771	15	106,945	14	23,749
Scranton, Pa	79	48,515	63	45,892	142	94,407	15	279,450	.....	.....
Seattle, Wash	7,583	7,553,395	3,586	1,141,514	11,169	8,694,909	36	370,940	(c)	(c)
Sioux City, Iowa	227	680,650	91	89,355	318	770,005	53	607,750	34	112,354
South Bend, Ind	814	314,972	.....	.....	814	314,972	41	630,355	.....	.....

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Spokane, Wash.	40	98,120	288	81,745	328	179,865	20	88,550	78	114,402
Springfield, Ill.	112	163,840	261	122,350	373	286,190	46	150,545	68	197,780
Springfield, Mass.	256	244,820	240	147,344	496	392,164	110	511,265	181	694,994
Superior, Wis.	302	224,320	492	149,342	794	373,662	7	106,095	20	80,275
Syracuse, N. Y.	408	471,660	699	338,505	1,107	810,165	37	440,190	63	279,429
Tacoma, Wash.	1,925	1,656,818	.....	.....	1,925	1,656,818	d 33	d 612,325	g 1,097	g 518,092
Tampa, Fla.	127	124,630	455	66,819	582	191,449	14	135,130	113	56,818
Terre Haute, Ind.	70	125,860	212	59,072	282	184,932	25	136,085	67	72,290
Toledo, Ohio.	608	783,300	629	478,168	1,237	1,261,468	110	1,249,626	66	117,188
Topeka, Kans.	102	64,668	56	21,928	158	86,596	9	31,935	13	50,544
Troy, N. Y.	4	9,000	120	70,920	124	79,920	4	27,500	73	85,457
Utica, N. Y.	196	441,940	92	82,115	288	524,055	27	276,400	18	69,250
Washington, D. C.	570	610,673	248	81,660	818	692,333	813	7,851,210	1,223	1,555,135
West Hoboken, N. J.	.....	.....	58	32,001	58	32,001	5	58,500	3	6,500
Wheeling, W. Va.	21	30,375	272	57,289	293	87,664	14	51,075	101	168,153
Wichita, Kans.	590	1,524,306	129	75,690	719	1,599,996	67	1,075,465	24	45,200
Wilkes-Barre, Pa.	101	69,352	190	31,693	291	101,045	51	238,507	142	99,983
Wilmington, Del.	.....	.....	14	36,518	14	36,518	707	2,336,526	50	612,665
Woonsocket, R. I.	102	78,090	65	32,705	167	110,795	13	259,600	8	20,700
Worcester, Mass.	527	535,602	.....	.....	527	535,602	d 110	d 766,072	h 558	h 765,060
Yonkers, N. Y.	60	167,100	14	21,700	74	188,800	34	702,400	21	194,300
York, Pa.	65	36,755	149	25,927	214	62,682	24	88,285	135	44,245
Youngstown, Ohio.	1,351	2,866,667	200	475,242	1,551	3,341,909	.....	.....	.....	.....
	63,304	89,786,648	60,802	27,428,361	124,106	117,215,009	16,079	134,628,524	32,285	48,862,366
Percentage of total	.....	24.1	.....	7.4	.....	31.5	.....	36.1	.....	13.1

For footnotes see p. 941.

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Building statistics of the leading cities of the United States in 1918—Continued.

City.	Fire-resisting buildings.									
	Stone.				Concrete.				Steel skeleton.	
	New.		Additions, alterations, and repairs.		New.		Additions, alterations, and repairs.		New.	
	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.
Allentown, Pa									2	$85,000
Altoona, Pa			25	$33,595						
Atlanta, Ga					1	$45,500				
Augusta, Ga					1	15,000				
Bayonne, N. J					5	124,500	2	$7,780		
Berkeley, Calif					5	170,000				
Birmingham, Ala	5	$14,975	9	4,080						
Boston, Mass	1	1,200	38	134,121	57	1,249,385	41	129,760	3	203,000
Bridgeport, Conn					47	36,590	2	200		
Buffalo, N. Y									27	856,000
Butte, Mont			2	590	6	2,110	4	2,125	2	72,000
Cambridge, Mass			3	5,900	13	487,050	17	105,925		
Camden, N. J									5	242,200
Cincinnati, Ohio					15	1,091,000	14	111,000		
Cleveland, Ohio					105	2,782,600				
Columbus, Ohio	2	1,000	2	5,200	26	391,490	13	88,525		
Dayton, Ohio					18	51,440	5	2,200		
Des Moines, Iowa		350,000			7	2,012,500				
Detroit, Mich					77	2,494,445	55	2,085,300	32	2,353,300
Dubuque, Iowa					5	68,500				
Duluth, Minn									3	190,000
East St. Louis, Ill	3	4,100								
Elizabeth, N. J					8	14,869	3	5,100		
Elmira, N. Y					5	17,400				
El Paso, Tex					4	120,500				
Fall River, Mass	3	1,600	5	54,700	19	19,571	3	1,900	2	167,500
Fitchburg, Mass	1	900			12	21,190	1	200		
Flint, Mich					15	274,460	1	3,500		
Fort Wayne, Ind	1	700	1	1,700	2	1,600	2	2,650		
Fort Worth, Tex	3	58,700			9	523,650	8	133,935		
Grand Rapids, Mich					13	43,875				
Harrisburg, Pa					2	76,000				
Hoboken, N. J					5	342,750				

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Houston, Tex					16	497,568	17	8,135		
Indianapolis, Ind					107	1,031,902				
Jacksonville, Fla	2	2,350			5	18,225	1	2,200		
Kalamazoo, Mich					13	66,038				
Kansas City, Kans					11	612,700				
Kansas City, Mo					22	2,727,000			1	150,000
Lawrence, Mass					55	71,315	6	5,175		
Lincoln, Nebr					4	9,000				
Little Rock, Ark	1	50,000								
Los Angeles, Calif					9	841,250	(b)	(b)		
Lynn, Mass					2	22,800	1	150		
Macon, Ga	1	46,000			1	30,000				
Malden, Mass					31	38,000				
Manchester, N. H			1	300	1	6,600				
Milwaukee, Wis					110	1,061,927			1	110,000
Minneapolis, Minn			17	16,345	26	22,000	16	9,540	47	1,073,335
Nashville, Tenn	1	3,500								
New Orleans, La					2	25,000				
New York:										
Bronx									3	560,000
Manhattan									46	5,376,580
Norfolk, Va					3	170,700	10	138,875		
Oakland, Calif					24	388,202				
Paterson, N. J					41	45,585	13	9,260		
Philadelphia, Pa	10	16,200	5	2,300	14	814,500	10	49,620	14	682,000
Portland, Oreg					14	1,462,165				
Providence, R. I	1	250,000	8	3,300	101	122,000	16	28,800	5	267,400
Pueblo, Colo			2	9,200	6	1,475	2	2,300		
Quincy, Ill					1	12,000				
Reading, Pa	2	16,700	63	19,875	35	291,600	18	5,650		
Rochester, N. Y					45	228,000	32	115,112		
Sacramento, Calif					3	110,000	9	5,658	2	308,352
Saginaw, Mich					2	46,000				
St. Joseph, Mo					2	255,000				
Salem, Mass					5	11,800				
San Antonio, Tex					24	1,350,200	1	3,000		
San Diego, Calif					2	11,000	14	16,900		
San Francisco, Calif	6	1,017,250	17	175,000	65	1,529,650	140	370,266		
Schenectady, N. Y			2	6,475	58	207,540	20	78,625	4	328,466
Seattle, Wash	c22	c593,380	554	364,590	f46	f631,054	155	211,170		
Sioux City, Iowa			10	1,601,100			1	6,000		
Springfield, Ill					2	800				
Superior, Wis					9	448,895				
Syracuse, N. Y					104	108,110				
Tampa, Fla	127	191,948								
Terre Haute, Ind					8	4,450				
Topeka, Kans	2	12,000	2	1,800	6	1,415				
Utica, N. Y					6	7,050				
Washington, D. C					11	90,850				
Wheeling, W. Va							6	33,560		
Wichita, Kans					32	344,070				

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Building statistics of the leading cities of the United States in 1918—Continued.

City.	Fire-resisting buildings.									
	Stone.				Concrete.				Steel skeleton.	
	New.		Additions, alterations, and repairs.		New.		Additions, alterations, and repairs.		New.	
	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.
Wilkes-Barre, Pa.					1	$80			1	$180,000
Wilmington, Del.					1	29,500				
Woonsocket, R. I.					6	7,118				
Yonkers, N. Y.	7	$8,400	2	$2,500	2	2,800				
Youngstown, Ohio	126	1,200,075	49	36,000						
	327	3,840,978	817	2,478,671	1,606	28,299,309	639	$3,780,096	200	13,195,103
Percentage of total		1.0		.7		7.6		1.0		3.5

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City.	Fire-resisting buildings.				General miscellaneous.		Grand total.		Rank in cost of building operations.
	Steel skeleton.		Total.						
	Additions, alterations, and repairs.								
	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	
Akron, Ohio			348	$1,944,150			2,185	$4,112,236	29
Albany, N. Y			541	707,781			1,600	1,286,226	68
Allentown, Pa			129	708,860			199	731,715	90
Altoona, Pa			43	55,375	145	$29,592	471	205,853	131
Atlanta, Ga			66	1,208,209	719	439,467	2,044	3,572,086	33
Atlantic City, N. J			31	70,506	1	150	398	530,661	107
Augusta, Ga			90	226,130	4	590	1,083	432,249	114
Baltimore, Md			4,541	4,811,251	600	189,312	6,170	5,390,483	20
Bayonne, N. J			30	239,465	29	35,533	157	440,478	113
Berkeley, Calif			10	226,500	5	35,000	615	722,290	91
Binghamton, N. Y			50	282,795			1,524	607,293	99
Birmingham, Ala	2	$355,500	281	1,070,635			3,001	1,765,172	60
Boston, Mass	9	18,175	1,347	6,224,798	30	365,985	3,977	7,704,190	13
Bridgeport, Conn			229	2,151,210			982	3,040,913	37
Brockton, Mass			6	53,000			245	273,803	127
Buffalo, N. Y			258	3,052,000			3,457	7,014,000	14
Butte, Mont	1	800	63	193,810	6	1,405	512	603,147	100
Cambridge, Mass	7	13,025	169	1,218,566	21	92,110	454	2,170,368	50
Camden, N. J			298	7,520,103	27	17,370	481	7,727,187	12
Canton, Ohio	2	18,000	70	303,920	324	273,987	917	1,845,067	57
Charleston, S. C			43	251,440			234	491,326	110
Chattanooga, Tenn	1	20,000	426	214,480	1,361	409,550	2,722	819,100	85
Cincinnati, Ohio	19	145,000	1,402	3,371,445	12	30,000	3,200	4,265,635	27
Cleveland, Ohio			908	9,348,100	32	876,500	8,668	16,385,800	4
Columbus, Ohio	2	33,600	510	2,494,630	67	19,870	1,824	3,301,220	39
Covington, Ky			62	93,550	24	6,600	140	142,800	139
Dallas, Tex			79	1,006,925			537	1,668,030	61
Dayton, Ohio	5	50,000	138	2,212,420			1,223	3,956,990	30
Denver, Colo			1,805	2,561,790	144	24,500	1,960	2,595,890	45
Des Moines, Iowa			105	3,506,263	15	9,150	670	4,460,566	26
Detroit, Mich	10	125,000	1,017	13,329,515			7,010	18,226,832	3
Dubuque, Iowa			12	99,900	4	109,344	67	273,019	128
Duluth, Minn			110	1,047,831			1,243	2,627,814	44

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Building statistics of the leading cities of the United States in 1918—Continued.

City.	Fire-resisting buildings.				General miscellaneous.		Grand total.		Rank in cost of building operations.
	Steel skeleton.		Total.						
	Additions, alterations, and repairs.								
	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	
East St. Louis, Ill			70	$712,221	88	$27,020	258	$886,086	82
Elizabeth, N. J			49	961,963	5	79,717	284	1,497,627	66
Elmira, N. Y			9	53,900			74	205,250	132
El Paso, Tex			640	558,620	169	15,776	1,041	626,121	98
Erie, Pa			114	499,322			1,145	2,148,083	51
Evansville, Ind			40	186,675	5	2,025	585	340,386	124
Fall River, Mass			63	455,151			277	644,496	94
Fitchburg, Mass			28	88,440	7	152,000	175	364,546	121
Flint, Mich			53	374,860			670	945,453	78
Fort Wayne, Ind			78	583,691			329	913,124	80
Fort Worth, Tex			186	1,703,805	14	25,280	646	2,267,887	49
Galveston, Tex			104	6,748	368	10,271	548	61,110	143
Grand Rapids, Mich			157	854,858	1	28,000	858	1,199,985	71
Harrisburg, Pa			129	841,515	13	30,510	219	910,865	81
Hartford, Conn			142	1,962,200			808	2,978,561	40
Hoboken, N. J			81	581,257	6	11,300	170	662,635	93
Holyoke, Mass			42	111,075			94	208,270	130
Houston, Tex			331	891,253	59	45,380	2,206	2,270,649	48
Indianapolis, Ind			601	1,856,494	515	669,084	4,308	4,558,676	25
Jacksonville, Fla			135	451,232	1,020	85,049	1,475	1,145,351	73
Kalamazoo, Mich			17	75,558			79	191,458	135
Kansas City, Kans			25	794,975			260	1,058,016	75
Kansas City, Mo			351	4,452,225	246	132,635	1,910	5,649,645	18
Knoxville, Tenn			76	166,885			785	643,345	95
Lancaster, Pa			159	282,640			159	282,640	126
Lawrence, Mass			100	1,648,608			221	1,852,308	56
Lincoln, Nebr			69	375,021			342	759,172	88
Little Rock, Ark			156	208,756			640	749,712	89
Los Angeles, Calif			1,340	2,601,051	1,323	391,505	6,381	8,678,802	9
Louisville, Ky			443	1,544,986			1,213	2,017,412	53
Lowell, Mass			71	515,795			550	1,342,362	67
Lynn, Mass	4	$1,300	26	246,197	6	1,210	209	361,670	122

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McKeesport, Pa.	1	100	36	128,125	2	850	173	209,049	129
Macon, Ga.			23	208,031	219	50,420	772	596,500	102
Malden, Mass.			53	244,420			262	400,420	118
Manchester, N. H.			33	70,335			562	320,862	125
Milwaukee, Wis.			259	1,988,884	8,689	1,722,346	11,043	6,513,096	15
Minneapolis, Minn.	92	198,330	605	2,780,510			3,695	5,395,740	19
Mobile, Ala.			9	49,125			53	80,784	142
Nashville, Tenn.			570	401,746			1,211	534,783	106
Newark, N. J.			462	3,410,736	124	15,739	1,096	5,336,033	22
New Bedford, Mass.			116	453,025			352	976,714	77
New Haven, Conn.			196	2,535,903	202	59,381	928	3,227,058	34
New Orleans, La.			78	920,421	3	40,000	542	1,770,930	59
New York:									
Brooklyn			3,235	18,382,225	84	281,820	4,824	21,566,382	
Bronx			325	4,546,085	1,367	368,320	1,847	5,207,320	
Manhattan	375	2,038,568	2,624	17,574,100			2,668	17,697,650	1
Queens			1,141	4,416,828	287	269,143	2,228	6,768,138	
Richmond			217	1,291,513	335	91,084	1,308	2,362,514	
Norfolk, Va.			142	1,594,128	118	86,795	591	2,834,107	41
Oakland, Calif.			74	1,192,364	5	189,000	2,948	5,382,160	21
Oklahoma, Okla.			14	443,000	204	42,225	849	2,510,221	46
Passaic, N. J.			33	256,075			181	390,520	119
Paterson, N. J.			194	653,514	33	71,198	823	1,087,540	74
Pawtucket, R. I.			18	355,000	96	25,527	229	552,492	105
Philadelphia, Pa.	8	14,500	5,657	14,970,250	112	325,125	5,820	15,340,500	5
Portland, Me.			66	343,592			303	601,647	101
Portland, Oreg.			492	2,149,100	188	789,770	5,707	6,176,047	17
Providence, R. I.	1	300	341	3,514,600			2,532	4,963,100	23
Pueblo, Colo.			187	187,665	61	35,314	442	374,796	120
Quincy, Ill.			9	79,400			14	95,700	141
Reading, Pa.	112	49,275	1,317	770,600	161	15,475	1,581	793,575	86
Richmond, Va.			566	1,539,024	90	38,153	949	1,838,614	58
Rochester, N. Y.			238	1,156,089	55	71,193	1,361	1,949,551	54
Sacramento, Calif.	1	51,574	187	858,062			653	1,213,513	70
Saginaw, Mich.			28	211,900			428	521,947	109
St. Joseph, Mo.			102	440,680			310	560,672	104
St. Louis, Mo.			2,252	5,805,732			5,396	6,352,582	16
St. Paul, Minn.			174	1,217,657	853	7,165,628	1,977	10,152,709	8
Salem, Mass.			8	32,050	1	500	358	189,546	136
Salt Lake City, Utah			552	2,219,605			721	2,319,695	47
San Antonio, Tex.			116	1,836,705	596	205,993	2,450	3,753,954	32
San Diego, Calif.			269	482,224	135	56,531	1,195	1,602,980	63
San Francisco, Calif.			476	5,562,146			3,688	7,924,319	11
Savannah, Ga.			27	576,200	107	28,850	241	768,675	87
Schenectady, N. Y.	1	17,430	114	769,230			652	1,230,001	69
Scranton, Pa.			15	279,450	28	52,489	185	426,346	115
Seattle, Wash.	(f)	(f)	793	2,171,134	54	10,143	12,016	10,876,183	6
Sioux City, Iowa			98	2,327,204			416	3,097,209	35
South Bend, Ind.			41	630,255			855	945,327	79
Spokane, Wash.			98	202,952	421	40,239	847	423,056	116
Springfield, Ill.			215	349,125			489	635,315	97

For footnotes see p. 941.

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Building statistics of the leading cities of the United States in 1918—Continued.

City.	Fire-resisting buildings.				General miscellaneous.		Grand total.		Rank in cost of building operations.
	Steel skeleton.		Total.						
	Additions, alterations, and repairs.								
	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	
Springfield, Mass			291	$1,206,259			787	$1,508,423	64
Superior, Wis.			36	635,265			830	1,008,927	76
Syracuse, N. Y.			294	827,729			1,311	1,637,894	62
Tacoma, Wash.			1,130	1,130,417	32	$9,265	3,087	2,796,500	42
Tampa, Fla.			254	383,896			836	575,345	103
Terre Haute, Ind.			100	212,825	230	57,972	612	455,729	112
Toledo, Ohio			176	1,366,814	116	31,879	1,529	2,660,161	43
Topeka, Kans.			32	97,894			190	184,290	137
Troy, N. Y.			77	112,957			201	192,877	134
Utica, N. Y.			51	352,700			339	876,755	84
Washington, D. C.			2,047	9,497,195	1,497	486,104	4,362	10,675,632	7
West Hoboken, N. J.			8	65,000	24	13,555	90	110,556	140
Wheeling, W. Va.			121	252,788			414	340,452	123
Wichita, Kans.			123	1,464,735			842	3,064,731	36
Wilkes-Barre, Pa.			195	518,570	133	20,895	619	640,510	96
Wilmington, Del.			758	2,978,991			772	3,015,209	38
Woonsocket, R. I.			27	287,418	1	5,000	195	403,213	117
Worcester, Mass.			668	1,531,132			1,195	2,066,734	52
Yonkers, N. Y.			66	910,400	16	57,800	156	1,157,000	72
York, Pa.			159	132,530			373	195,212	133
Youngstown, Ohio			175	1,236,075			1,726	4,577,984	24
	653	$3,150,477	52,606	238,235,524	24,074	17,504,495	200,786	372,955,028	
Percentage of total		.8		63.8		4.7		100.0	

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City.	Grand total.		Rank in cost of building operations.
	Number of permits or buildings.	Cost.	
Chicago, Ill	2,529	$34,792,200	2
Haverhill, Mass	93	161,735	138
Jersey City, N. J	684	4,232,693	28
Memphis, Tenn	643	1,591,078	65
New Britain, Conn	480	880,990	83
Newton, Mass	352	469,423	111
Peoria, Ill	532	1,941,163	55
Pittsburgh, Pa	2,571	7,938,350	10
Somerville, Mass	192	676,470	92
Trenton, N. J	425	522,615	108
Waterbury, Conn	1,251	3,852,620	31
Grand total	210,538	430,014,365	

[a] Additions to all classes of buildings for Atlantic City, Binghamton, and Erie are included with additions, etc., to wooden buildings.
[b] Additions to concrete and cement buildings for Los Angeles are included with additions, etc., to brick buildings.
[c] Additions, etc., to brick buildings for Newark are included with additions, etc., to wooden buildings.
[d] All classes of new fire-resisting buildings for New Haven, Worcester, and Tacoma are included with new brick buildings.
[e] Additions, etc., to brick buildings for Seattle are included with new stone buildings.
[f] Additions, etc., to steel skeleton buildings for Seattle, are included with new concrete buildings.
[g] Additions, etc., to all classes of buildings for Tacoma are included with additions, etc., to new brick buildings.
[h] Additions, etc., to all classes of buildings for Worcester are included with additions, etc., to new brick buildings.

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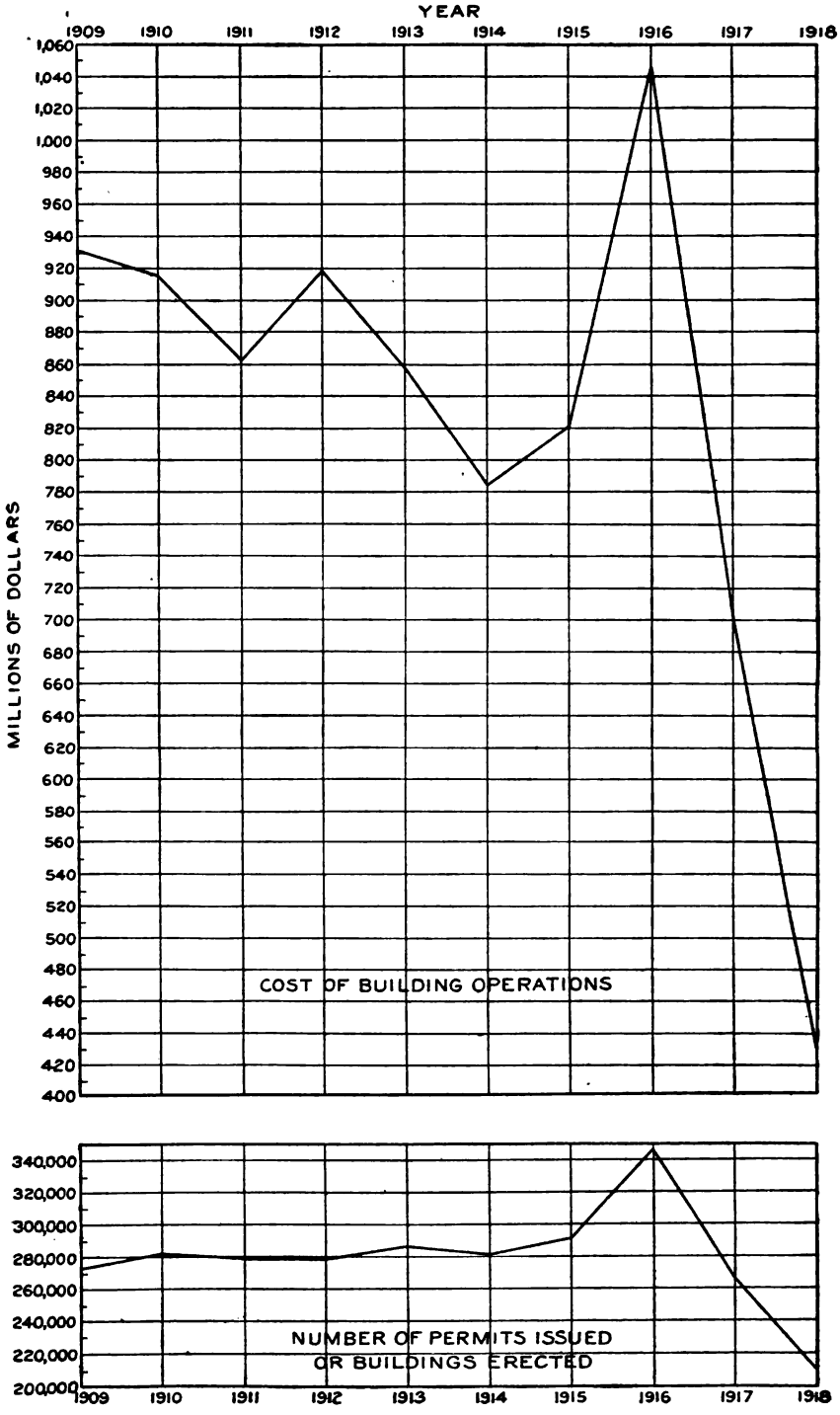

FIGURE 98.—Diagram showing building operations in some of the larger cities of the United States, 1909–1918.

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The statistics given in the following table are shown graphically in figure 98.

Building operations in the larger cities of the United States, 1909–1918.

Year.	Number of cities.	Number of permits or buildings.	Cost.	Average cost per permit or building.
1909	137	273,883	$930,520,713	$3,398
1910	145	282,661	916,353,775	3,242
1911	145	279,017	863,968,860	3,096
1912	143	278,129	919,809,054	3,307
1913	147	285,850	859,657,250	3,007
1914	147	281,174	785,525,746	2,794
1915	144	292,707	821,120,657	2,805
1916	146	347,761	1,046,276,549	3,009
1917	145	266,698	700,700,815	2,627
1918	143	210,538	430,014,365	2,042

The 143 cities included in the accompanying tables reported building operations costing $430,014,365 in 1918. Practically the same cities reported building operations costing $700,700,815 in 1917, and $1,046,276,549 in 1916, a decrease of 39 per cent compared with 1917 and of 59 per cent compared with 1916. The average cost per operation in these 143 cities in 1918 was $2,042, the lowest in ten years, and was 40 per cent lower than the maximum of 1909.

Of this number 132 cities reported sufficient detail to permit the publication of statistics of operations by classes of structures. These cities reported 200,786 permits or buildings that cost $372,955,028. Of this amount new operations of every kind, represented by 81,516 permits or buildings, cost $269,750,562, or 72 per cent of the total; additions, alterations, and repairs, represented by 95,196 permits or buildings, cost $85,699,971, or 23 per cent of the total; and miscellaneous operations, represented by 24,074 permits or buildings, cost $17,504,495, or nearly 5 per cent of the total. In 1917 practically the same cities reported 247,954 permits or buildings, costing $645,980,162, of which 105,018 operations for new work, cost $530,416,779, or 82 per cent of the total; additions, alterations, and repairs, represented by 101,094 permits or buildings, cost $92,434,292, or 14 per cent; and 41,842 miscellaneous and undistributed operations cost $23,129,091, or 4 per cent.

The statistics of building operations by kinds, especially the totals, are only approximate, for many cities were unable to report strictly in accordance with the classification given in the table, but it is believed that the figures published are accurate enough to give a good idea of the relative importance of the various kinds of operations enumerated.

The rank of the several cities in the different classes of building operations is relative, not actual, as the expenditures in some cities that reported no details may have exceeded those in some cities that reported the cost of buildings by classes.

Taken by classes the new wooden buildings in these 132 cities in 1918 cost $89,786,648, or 24 per cent of the total; new brick or hollow tile buildings cost $134,628,524, or 36 per cent of the total; new stone buildings cost $3,840,978, or 1 per cent of the total; new concrete buildings cost $28,299,309, or 8 per cent; and new steel skeleton buildings cost $13,195,103, or nearly 4 per cent. Of the new buildings those constructed of wood cost 33 per cent of the total for new buildings; new fire-resisting buildings cost $179,963,914, or 67 per cent; those of

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brick or hollow tile, 50 per cent; those of stone, 1 per cent; those of concrete, nearly 11 per cent; and steel skeleton buildings, 5 per cent.

Of the cost of all additions, alterations, and repairs, $27,428,361, or 32 per cent, was for wooden buildings. Additions, alterations, and repairs to fire-resisting buildings cost $58,271,610, or 68 per cent. Of the fire-resisting buildings, additions to brick or hollow tile buildings cost $48,862,366, or 57 per cent; those to stone buildings cost $2,478,671, or 3 per cent; those to concrete buildings, $3,780,096, or 4 per cent; and those to steel skeleton buildings, $3,150,477, or 4 per cent.

The cost in these cities of all operations on wooden buildings was $117,215,009, or nearly 32 per cent of the total cost of all building operations; brick or hollow tile buildings, new and additions, alterations, and repairs, cost $183,490,890, or nearly 50 per cent; stone buildings $6,319,649, or nearly 2 per cent; concrete buildings $32,079,405, or nearly 9 per cent; and steel skeleton buildings $16,345,580, or 4 per cent of the total.

The decline in the erection of new buildings and the tendency to economize by an increased resort to alterations, additions, and repairs are shown by the following table:

Percentage of cost of different classes of building operations in 132 cities, 1917 and 1918.

	1917	1918
New construction	82	72
Alterations, additions, and repairs	14	23
Miscellaneous, including undistributed operations	4	5

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FELDSPAR.

By L. M. Beach.

PRODUCTION.

There was a decrease of approximately 30 per cent in the quantity of feldspar marketed in this country in 1918, as compared with 1917. The industry was showing a healthy growth in 1916 and 1917 and during the early part of 1918, but later in the year the exigencies of war caused production to decrease. The main causes of the decrease were the scarcity of labor, the curtailment of fuel supply to the pottery industry, which was deemed nonessential, and shortage of railroad service. This decline in production was partly compensated by higher prices.

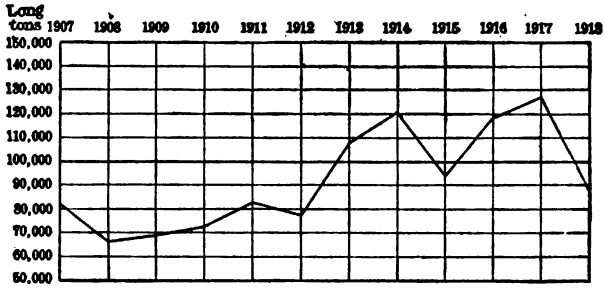

Figure 99.—Diagram showing annual output of crude feldspar, 1907–1918.

Crude feldspar sold for an average price of $4.65 a long ton in 1918; the average price in 1917 was $3.40 a ton, and in 1916 it was $3.34. The range of prices in 1918, according to reports received by the United States Geological Survey, was from $1.75 to $10.50 a long ton; in 1917 the range was from $2 to $7 a ton. Ground feldspar was marketed at an average price of $12.33 a short ton, compared with $10.15 in 1917 and with $9.30 in 1916. The reported range of prices for ground feldspar in 1918 was from $4.76 to $18 a short ton; in 1917 it was from $5.70 to $17 a ton.

Of the total production in 1918, 68 per cent was sold crude and 32 per cent ground; in 1917, 70 per cent was sold crude, and in 1916, 63 per cent. North Carolina is credited with the production of a certain quantity of feldspar which is ground in Tennessee before it is sold. The total quantity of ground spar sold in the United States in 1918 was approximately 32,000 short tons.

Producers of feldspar sell the crude material by the long ton. The following table shows the quantity of feldspar produced in each State whether first marketed as crude or ground spar, but the value given is an estimated average for crude spar in each State.

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Feldspar sold in 1917 and 1918, and value at price for crude feldspar.

State.	1917		1918	
	Quantity (long tons).	Value.	Quantity (long tons).	Value.
California	7,031	$18,137	1,296	$8,839
Connecticut	a 10,455	a 43,100	5,305	29,419
Maine	31,720	131,994	22,656	105,430
Maryland	14,088	56,958	7,873	40,299
New York	12,019	44,290	11,277	58,076
North Carolina	42,403	131,442	35,732	160,275
Pennsylvania	8,939	48,786	4,389	27,651
	126,715	474,767	88,498	429,989

a Includes New Hampshire.

Many feldspar miners grind their spar and market it in the ground form and by the short ton; hence the following table is given in short tons. The quantities given in this table are the same as in the preceding table, converted from long to short tons. The values for each State, however, are the sum of sales of both crude and ground spar and represent the money actually paid for the spar when first marketed.

Crude and ground feldspar sold in 1917 and 1918.

State.	1917		1918	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.
California	7,874	$18,543	1,451	$8,839
Connecticut	a 11,710	a 77,432	5,942	52,117
Maine	35,527	291,252	25,376	283,957
Maryland	15,779	56,958	8,784	40,299
New York	13,462	62,003	12,681	71,590
North Carolina	47,559	131,442	40,020	160,275
Pennsylvania	10,013	91,208	4,916	57,269
	141,924	728,838	99,120	674,346

a Includes New Hampshire.

FELDSPAR INDUSTRY, BY STATES.

The sales of feldspar in 1918 were reported from the following States, named in the order of their output: North Carolina, Maine, New York, Maryland, Connecticut, Pennsylvania, and California; named in order of the value of their output the States were Maine, North Carolina, New York, Pennsylvania, Connecticut, Maryland, and California.

California.—Six quarries, operated by six separate firms, three located in Tulare County, two in Riverside County, and one in Monterey County, reported production in 1918, as against 10 quarries operated by eight firms, working four in Riverside County, and one each in Tulare, San Bernardino, Monterey, and Los Angeles counties in 1917. The production in 1918 amounted to 1,296 long tons of crude product, valued at $8,839. The figures for 1917 were 7,031 long tons, valued at $18,137. Crude feldspar sold for $4 to $7 a long ton in California at the quarries; pottery grades averaged about

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$6.95. The pottery grades sold for $4.50 a long ton in 1917, and the crude ranged between $2 and $7.80 f. o. b. quarries.

Connecticut.—In 1918 three Connecticut firms reported feldspar production, two operating in Hartford and Middlesex counties, and one at Willimantic, in Windham County. As in 1917 there was a decrease, only 5,305 long tons of crude product, valued at $29,419, being produced. This feldspar was used chiefly in pottery and enameling, the remainder selling for use in abrasives and scouring soaps. The quantity of crude feldspar produced in Connecticut in 1917 was larger, but the unit prices were much below those obtained in 1918. The prices on crude spar ranged in 1918 between $5.96 and $10.50 a long ton f. o. b. quarries; the range in 1917 was between $4 and $7. Ground feldspar brought from $10.50 to $20 a short ton f. o. b. mills in 1918, whereas in 1917 the prices ranged from $8.90 to $17.

Delaware.—Wilmington is a very important feldspar market, and several grinding mills are located there. There was no production of feldspar in Delaware in 1918.

Maine.—Maine ranked second in output and first in value of feldspar produced in 1918. The number of operators reporting production in 1918 was five, as compared with six in 1917, and the number of active quarries decreased from nine to seven. The total output of feldspar in 1918 was 22,656 long tons of crude, valued at $105,430, a decrease in both quantity and value from the preceding year, when 31,720 long tons produced sold for $131,994. The Maine Feldspar Co., operating mills at Topsham, in Sagadahoc County, and at Auburn, in Androscoggin, and the Trenton Flint & Spar Co., at Cathance, Sagadahoc County, produced and sold most of the State's output. In 1918 prices of crude feldspar ranged between $4.25 and $5.80 a long ton, as compared with $3 and $4.50 received in 1917; and prices of ground feldspar were $12.28 to $14 in 1918, against $11 to $11.30 in 1917. A large portion of the output in 1918 went to the pottery trade; some was used in the preparation of ceramic binders for carborundum and corundum grinding wheels; and a small portion went into the manufacture of abrasive soaps.

Maryland.—Ten operators in Maryland reported production in 1918, an increase of three over 1917. Notwithstanding this, however, the State dropped from third to fourth place in the quantity of spar produced. The output in 1918 amounted to 7,843 long tons of crude spar; prices ranged from $4 to $6.16 a long ton and averaged $5.14 f. o. b. quarries; in 1917 there were 14,088 long tons produced, which sold at $3 to $4.50 a long ton and averaged $4.04 f. o. b. quarries. The principal quarries are located in Baltimore, Howard, Carroll, and Cecil counties.

New Hampshire.—No feldspar was quarried in New Hampshire in 1918, although in previous years this State had been an active producer, its spar going into the manufacture of scouring soaps.

New Jersey.—Trenton is an important feldspar market and the location of several grinding mills. There are no deposits in New Jersey.

New York.—New York was an active producer of feldspar in 1918 and ranked third among the producing States of the Union instead of fourth as in 1917. In the value of its yield New York rose from fifth place in 1917 to third place. The output was 11,277 long tons

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of crude feldspar in 1918, as against 12,019 long tons in 1917. This slight decrease was counterbalanced by the good prices prevailing, the output in 1918 selling for $58,076, as compared with $44,290 in 1917. Pottery spar in the crude sold for $3.92 to $6 a long ton in 1918, as compared with $3 to $4.50 a ton in 1917. Crude feldspar sold for an average price of $4.60 in New York in 1918, against $3.05 in 1917, and ground feldspar sold for $8 in 1918, as compared with $7.04 in 1917.

Three companies, located in Essex, Westchester, Monroe, and St. Lawrence counties, reported operations in New York. The greater portion of the output of spar was consumed as roofing, concrete facing, and chicken grits, the remainder going into enamel ware and pottery products.

North Carolina.—North Carolina ranked first in quantity and second in value of its production in 1918, although only 10 quarries reported operations during the year, compared with 24 in 1917. The principal operations were confined to Mitchell, Avery, and Yancey counties. The output of crude feldspar in 1918 was 35,732 long tons, valued at $160,275, as against $131,442 received in 1917 for 42,463 long tons. Prices ranged from $2 to $6 a ton, the prevailing price was $4.50, and the average was $4.49. In 1917 the range was between $2.60 and $7 a ton, the prevailing price was about $4, and the average price was $3.10. As in 1917, much of the product in 1918 was ground at Erwin, Tenn., and the remainder went to the mills at East Liverpool, Ohio, and Trenton, N. J.

Pennsylvania.—Pennsylvania ranked sixth in quantity and fourth in value of production of feldspar. Three producers reported activity during 1918 as compared with 10 in 1917. The spar was taken from three large quarries and a number of smaller ones in Chester and Delaware counties. The total production was 4,389 long tons of crude spar, valued at $27,651 f. o. b. mines. There was 8,939 long tons mined and sold in 1917, valued at $48,786. The greater part of the output in 1918 was quarried at Brandywine Summit and Toughkenamon. Prices for crude spar averaged $5 a ton in 1918, a few cents less than the average in 1917. Ground feldspar sold from $8.58 to $18, and averaged $12.45 a ton in 1918; in 1917 the range was between $7.20 and $12, and the average was $10.25. Feldspar is used principally in Pennsylvania in the manufacture of glassware, pottery, abrasive soaps, and chicken grits.

Vermont and Virginia.—No production of feldspar was reported either in Vermont or Virginia for the year 1918.

FELDSPAR IN CANADA.

The following tabulation chronicles the feldspar industry activities in Canada in 1918 and other recent years. The United States imports practically all of the Canadian product, although it does not import feldspar from any other country.

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Feldspar sold in Canada, 1913–1918.[a]

Year.	Quantity (short tons).	Value.	Year.	Quantity (short tons).	Value.
1913	15,935	$56,841	1916	19,488	$71,407
1914	18,060	70,824	1917	11,493	54,555
1915	15,455	59,124	1918[b]	20,232	117,379

[a] Statistics taken from reports on the mineral production of Canada, Canada Dept. Mines.
[b] Figures for 1918 preliminary and subject to revision.

FELDSPAR MILLS.

Exclusive of mills operated by feldspar consumers for grinding spar for their own use, there are mills in the Eastern States operated by the following firms, dealers in feldspar, at the places named: Maine Feldspar Co., Auburn and Topsham, Maine; Trenton Flint & Spar Co., Cathance, Maine; Louis W. Howe, South Glastonbury, Conn.; Bedford Mining Co., Bedford, N. Y.; Pennsylvania Feldspar Co., Barnard, N. Y., and Toughkenamon, Pa.; Brandywine Summit Kaolin & Feldspar Co., Brandywine Summit, Pa.; Eureka Flint & Spar Co., Trenton, N. J.; Golding Sons Co., Trenton, N. J., Wilmington, Del., and East Liverpool, Ohio; Potters Mining & Milling Co., East Liverpool, Ohio; Newell Mining & Pulverizing Co., Newell, W. Va.; Clinchfield Products Corporation, Erwin, Tenn.; and Rochester Feldspar Mills (Inc.), Rochester, N. Y.

USES.

Most of the high-grade feldspar is used in the manufacture of ceramic products; it is also used as an abrasive in the manufacture of scouring soaps and window wash. A small quantity of the purest material is used in making artificial teeth.

The lower grades of feldspar are used as a binder in the manufacture of emery and corundum wheels, in the manufacture of glass, in roofing material, and for concrete work.

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BARYTES.

By GEORGE W. STOSE.[1]

CRUDE BARYTES.

PRODUCTION.

In 1918 the domestic crude barytes marketed in the United States amounted to 155,368 short tons, valued at $1,044,905. This marks a steady decrease in sales since the climax was reached in 1916, when nearly 222,000 tons was sold. (See table below.) This decrease was due not so much to a decline in the demand for barium products as to the scarcity and high cost of labor. There was a decrease in 1918 of 25 per cent in quantity from the output in 1917 and of 30 per cent from that in 1916, but the value of the output in 1918 was somewhat greater than that of 1916 and less than that of 1917. The average price per ton increased from $4.56 in 1916 to $5.66 in 1917 and to $6.73 in 1918. The large output in 1916 was about double that of 1915 and more than four times the output of 1914.

Crude barytes produced and marketed in the United States, 1880–1918.

	Quantity (short tons).	Price per ton.
Annual average for 10 years 1880–1889	21,410	.....
Annual average for 10 years 1890–1899	27,523	.....
Annual average for 10 years 1900–1909	58,310	.....
Annual average for 5 years 1910–1914	43,389	$3.31
1915	108,547	3.51
1916	221,952	4.56
1917	206,888	5.66
1918	155,368	6.73

Crude barytes produced and marketed in the United States, by States, 1916–1918.

State.	1916			1917			1918		
	Quantity (short tons).	Value.	Average price per ton.	Quantity (short tons).	Value.	Average price per ton.	Quantity (short tons).	Value.	Average price per ton.
Alabama	7,631	$27,198	$3.56	1,976	$8,868	$4.49	1,794	$9,976	$5.56
Colorado	481	3,005	6.25	.....	.....	.....	.....	.....	.....
Georgia	104,784	401,295	3.83	111,300	601,895	5.41	69,318	418,178	6.03
Kentucky	11,068	54,995	4.97	6,720	36,084	5.37	(a)	(a)	.....
Missouri	58,223	365,111	6.27	59,046	391,363	6.63	49,094	393,738	8.02
North Carolina	878	3,246	3.70	1,019	5,080	4.99	(a)	(a)	.....
Tennessee	32,416	123,986	3.85	16,972	79,058	4.66	22,542	141,844	6.29
Other States b	6,471	32,396	5.01	9,855	48,836	4.96	12,620	81,169	6.43
	221,952	1,011,232	4.56	206,888	1,171,184	5.66	155,368	1,044,905	6.73

a Included in "Other States."
b Includes, 1916 and 1917: California, Nevada, South Carolina, and Virginia; 1918: Kentucky, Nevada, New Mexico, North Carolina, South Carolina, Virginia, and Wisconsin.

[1] The statistical data in this report were prepared by Miss L. M. Jones, of the United States Geological Survey.

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Georgia led all other States in production in 1918, marketing 20,000 tons more than its nearest competitor, Missouri. Georgia's rate of decrease since 1917, its banner year, was 38 per cent, whereas Missouri's rate of decrease was only 17 per cent. Tennessee, the only other State that supplied a considerable part of the production, increased its output about 33 per cent in 1918, although it did not reach its production of 1916, its record year, by nearly 10,000 tons. New Mexico and Wisconsin were added to the producing States, although the quantity marketed by each was small. The production of Kentucky, Nevada, New Mexico, North Carolina, South Carolina, Virginia, and Wisconsin can not be given separately, as there were less than three firms that produced barytes in any one of these States in 1918. The production of each except Kentucky was small, the total sales from these seven States amounting to only 12,620 short tons, or 8 per cent of the total for the United States.

No sale of barytes was reported from California, which was one of the small producers in 1917. Illinois did not market any barytes in 1918 but mined a considerable quantity of this ore with fluorite at mines in the southern part of the State and for the first time successfully separated these ores in a commercial plant. Illinois is therefore expected to enter the producing column in 1919.

STOCKS AT MINES.

In general, barytes is marketed as soon as it is mined, but car shortage and railroad embargoes caused considerable delay in delivery in some parts of the country both in 1917 and 1918 and some operators were unable to market their product promptly. The stocks held at the mines are not included in the preceding table, whereas stocks held by makers of barium products at their mills have entered the market and are included. Apparently about 18,500 short tons of barytes remained in stock in the hands of mine operators on December 31, 1918, as compared with about 20,000 short tons on December 31, 1917. Of this total about 5,700 tons was held by mine operators in Tennessee, 5,500 tons in Missouri, and nearly 4,000 tons in Georgia. This was a decided decrease of stock for Georgia and a large increase for Tennessee, which apparently means that the actual production of Georgia for 1918 was about 2,000 tons less than was marketed and that the production of Tennessee was about 2,000 tons more than was marketed.

IMPORTS.

No barytes was imported into the United States in 1918, and the manufacturers of barium products in this country had to depend for their crude ore entirely on the domestic material. The accompanying table shows how imports declined during the war from 24,423 short tons in 1914 to 17 short tons in 1916 and to none in 1918.

Crude barytes imported for consumption, 1912–1918.

Year.	Quantity (short tons).	Value.	Year.	Quantity (short tons).	Value.
1912	26,186	$52,467	1916	17	$245
1913	35,840	61,409	1917	6	63
1914	24,423	46,782	1918	0	0
1915	2,504	4,877			

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This sudden almost complete cessation of imports of barytes in 1915 was caused by the war with Germany, from which most of the foreign barytes has come. The importation of crude barytes from Germany will probably be resumed on a greater scale than before the war, unless discouraged by a tariff. German barytes with a low duty will be much cheaper than domestic ore near the Atlantic seaboard and will probably monopolize most of the eastern trade and cause practically all the mines in the Appalachians to close down. The barium-products industries in the United States, which have greatly expanded during the last few years, will require more raw material than had been mined before the war. The known and readily accessible deposits of barytes in this country are much smaller than those of Germany and more costly to mine, so that it is not reasonable to depend on American deposits for a permanent source of all the barytes needed for the home industries. The tariff of 15 per cent ad valorem, at present in force, will probably not be sufficient to maintain the eastern mines.

MARKETS.

About one-third of the barytes used in the manufacture of barium products in 1918 was ground and floated or otherwise refined and sold as such to manufacturers of paint and other material; almost half was made into lithopone; and the remainder was made into barium chemicals, including blanc fixe, also a paint base. The following table shows the quantities used in these branches of the industry:

Crude barytes used in the manufacture of barium products, 1915–1918, in short tons.

Year.	Manufacture of ground barytes.	Manufacture of lithopone.	Manufacture of barium chemicals.	Total.
1915	53,903	44,503	10,216	108,622
1916	75,507	71,898	38,283	185,688
1917	60,132	86,065	49,842	196,039
1918	62,440	85,282	38,041	185,763

Prior to 1914 the market for crude barytes in the United States centered around two localities—St. Louis, Mo., and Philadelphia, Pa. In the St. Louis district the mineral was used chiefly by manufacturers of ground and refined barytes. In the Philadelphia district some domestic barytes was used also in the manufacture of lithopone, but most of the material used for this purpose was imported from Germany. Since 1914 many lithopone and chemical plants have been established, most of them east of the Mississippi and north of the Ohio, so that the chief markets have remained about the same. But a considerable manufacturing industry has sprung up in the South around Cartersville, Ga., Sweetwater and Johnson City, Tenn., and Charleston, W. Va., and smaller operations have been started in Ohio, Kentucky, and California.

In Missouri much of the mining is done on a small scale by many operators, and their output is bought by agents of one or the other of several large manufacturing companies of St. Louis, Mo., Mineral

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Point, Mo., and Chicago, Ill. The J. C. Finck Mineral & Milling Co., of St. Louis, made the largest purchases in 1918, and the Nulsen, Klein & Krausse Manufacturing Co. was the next largest buyer. In the Southern States most of the ore is mined by the larger manufacturing companies for their own use.

PRICES.

The prices obtained for crude ore f. o. b. mines were much higher in 1918 than in 1917 or in any previous year. (See table, p. 951.) The average price received for the total output in the United States was $6.73 per short ton, which is nearly 50 per cent higher than the average price in 1916 ($4.56) and considerably more than double the average price in 1914 ($2.95). The price, however, was not the same in different districts and changed also during the year. The average price for 1918 received by the operators in Missouri was $8.02, and some sales were reported to have brought as much as $10 a ton. The prices obtained in States east of the Mississippi ranged from $4.46 to $7.14 a short ton, the average price in Georgia, the largest producing State, being $6.03.

CONSUMPTION.

The consumption of barytes in the United States can be computed only approximately from the records available, because the stocks on hand at the plants of the manufacturers of the barium products can not be determined. The apparent consumption as stated in the following table is determined by adding the imports to the sales of domestic ore. As there were no imports or exports of barytes in 1918, the apparent consumption is the same as the quantity of domestic barytes sold or used.

Crude barytes apparently consumed in United States, 1912–1918, in short tons.

Year.	Sales of domestic barytes.	Imports for consumption.	Apparent consumption.
1912	37,478	26,186	63,664
1913	45,298	35,840	81,138
1914	52,747	24,423	77,170
1915	108,547	2,504	111,051
1916	221,952	17	221,969
1917	206,888	6	206,894
1918	155,368	0	155,368

The comparison of this table with the table given under the heading Markets, which shows the crude ore used in the various barium-products industries, reveals a discrepancy which represents approximately differences in the stocks of crude ore held by the manufacturers.

BARYTES INDUSTRY, BY STATES.

Alabama.—There was little activity in the barytes industry in Alabama in 1918, only 1,794 short tons being marketed. This was about 200 tons less than was sold in 1917. The ore came chiefly from two mines in Calhoun County and a mine near Centerville, Bibb County. Small quantities were also mined in Shelby County.

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Georgia.—The large quantity of barytes marketed in Georgia, amounting to 69,318 short tons in 1918, valued at $418,178, came entirely from Bartow County. Most of it was obtained from seven mines around Cartersville, but about 10,000 tons came from mines near Emerson. Although the State still ranks first in the production of barytes, it lost ground in 1918, its output having declined 38 per cent from that of 1917, which was 111,300 tons. The largest quantity was marketed by the Paga Mining Co., of Cartersville, Ga., which operated three mines but handled only crude ore. All the large plants in the Eastern States that manufacture either ground barytes or lithopone operate mines in Georgia. The Krebs Pigment & Chemical Co., of Newport, Del., operating a mine at Cartersville under the name of the Krebs Mining Co., was the next largest operator, followed in order by the Bertha Mineral Co., mining for the New Jersey Zinc Co., E. I. du Pont de Nemours & Co., of Wilmington, Del., Nulsen, Klein & Krausse Manufacturing Co., Thompson, Weinman & Co., and several smaller operators.

Illinois.—Although no barytes was marketed in Illinois, considerable barytes was mined with fluorspar at Golconda. An attempt had not heretofore been made to separate these two ores, but they are now successfully separated by the use of jigs, and the Illinois product will shortly be put on the market.

Kentucky.—The quantity of barytes marketed in Kentucky in 1918 showed a decline of nearly 10 per cent from the production of 1917. Most of the output came from mines operated by the Central Pigment Co. at Hanly, Jessamine County, and Nicholasville, Woodford County, and was ground in the company's plant at Nicholasville. The mines in Fayette County, from which most of the output came in 1917, were idle in 1918, as were many others in the State. Several mines that changed ownership may be revived later.

Missouri.—The barytes marketed in Missouri in 1918 amounted to 49,094 short tons, valued at $393,738. This compares favorably with the value in 1917 but not with the quantity, which was 59,046 tons. The price received for the ore in 1918 averaged $8.02 a ton, as compared with $6.63 in 1917.

Three-fourths of the ore mined came from Washington County. The quantities marketed by the leading counties were approximately as follows: Washington County, 37,000 short tons; Cole County, 2,700 tons; Jefferson County, 2,100 tons; and St. Francois County, 1,800 tons. Most of the remainder came from Franklin, Miller, and Morgan counties. The largest single producer was the Nulsen, Klein & Krausse Manufacturing Co.'s mine at Cadet, Washington County, and the next largest was the Missouri Lincoln Trust Co.'s mine at Mineral Point, Washington County. As usual, the Nulsen, Klein & Krausse Manufacturing Co. and the J. C. Finck Mineral & Milling Co., both of St. Louis, Mo., and the Point Milling & Manufacturing Co., of Mineral Point, Mo., were the principal buyers of crude barytes from the smaller operators.

A description of the barytes deposits of Missouri and of the geology of the barytes district has recently been published.[1]

[1] Tarr, W. A., The barite deposits of Missouri and the geology of the barite district: Missouri Univ. Studies, vol. 3, No. 1, 1919. Review by G. W. Stose, Econ. Geology, vol. 14, No. 1, pp. 267-269, 1919.

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Nevada.—Deposits near Kinkead, Esmeralda County, and Hawthorne, Mineral County, Nev., yielded considerable barytes in 1918, which was shipped to West Berkeley and San Francisco and used in the refined barytes and barium chemical trade.

New Mexico.—The first barytes ore to be marketed in New Mexico was mined in 1918 at Las Cruces, Dona Ana County, and a trial shipment of the ore was sent to El Paso, Tex.

North Carolina.—Not more than 200 tons of barytes was mined in Madison County, N. C., in 1918. Several properties changed hands, and larger production is expected in 1919.

South Carolina.—Deposits at Kings Creek, Cherokee County, S. C., were mined as usual during 1918 by the Cherokee Chemical Co., and the product was ground in its mill at Kings Creek. The output for the State, however, was less than one-fourth of the quantity marketed in 1917.

Tennessee.—Tennessee mines marketed 22,542 short tons of barytes in 1918, valued at $141,844, a great increase over the production in 1917, which was 16,972 tons, valued at $79,058. Sweetwater, Monroe County, was the center of production, and the mines are located in the three adjoining counties of Monroe, McMinn, and Loudon. McMinn County alone sold 9,957 tons. The Durex Chemical Co., whose chemical plant is at Sweetwater, Monroe County, was the largest producer and mined barytes in all three counties.

Virginia.—The deposits at Evington, Campbell County, Va., were actively mined in 1918 by the Clinchfield Products Corporation for use in its chemical plant at Johnson City, Tenn. The quantity produced and used was more than three times that produced in 1917.

Wisconsin.—A small quantity of barytes was mined with lead ore at the lead mines at Cuba, Lafayette County, Wis., and was marketed in 1918. None had previously been produced in Wisconsin, but the output will probably not be large.

DOMESTIC PRODUCERS OF CRUDE BARYTES.

Firms that produced 100 tons or more of barytes in 1918, by States in which mines are situated.

ALABAMA.

Angel Mining Co., Rome, Ga.
Glidden Barytes Co., 506 First National Bank Building, Birmingham, Ala.
C. T. Weldon, Wilsonville, Ala.

GEORGIA.

Bertha Mineral Co., Cartersville, Ga.
Big Tom Barytes Co., Cartersville, Ga.
E. I. du Pont de Nemours & Co., Wilmington, Del.
Krebs Mining Co., Newport, Del.
Nulsen, Klein & Krausse Manufacturing Co., Levee and Sidney Streets, St. Louis, Mo.
Paga Mining Co., Cartersville, Ga.
Thompson, Weinman & Co., Cartersville, Ga.

ILLINOIS.

Little Jean Mining Co., Golconda, Ill.

KENTUCKY.

Central Pigment Co., Strand Building, Forty-seventh Street and Broadway, New York, N. Y.

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MISSOURI.

John K. Anderson, Centertown, Mo.
Bernhardt & Cole, Vineland, Mo.
T. F. Blount & Co., Palmer, Mo.
Samuel Boyer, Baryties, Mo.
Wm. Brazier, Eugene, Mo.
Bust Bros., Tiff, Mo.
A. H. Carr, Potosi, Mo.
H. C. Carter & Co., Halifax, Mo.
William Catlett, Cadet, Mo.
Frank A. Clancy, Baryties, Mo.
L. E. Cole & Co., Blackwell, Mo.
Connolly & Thurman, Potosi, Mo.
E. F. Cordia, Potosi, Mo.
Miss Stella Cummins, Baryties, Mo.
J. D. De Clue, Richwoods, Mo.
John Degonia, Baryties, Mo.
Ode Engledon, Blackwell, Mo.
P. G. Higginbotham, Fertile, Mo.
Ill-Mo Mineral Products Co., St. Clair, Mo.
Johnson Bros., Fletcher, Mo.
Jesse Joplin & Son, Old Mines, Mo.
Wm. Lenkart, Hopewell, Mo.
Thomas Maddin, Blackwell, Mo.
Missouri Lincoln Trust Co., H. L. White, agent, Potosi, Mo.
George B. H. Moore, Mineral Point, Mo.
Patrick Murphy, Old Mines, Mo.
Nulsen, Klein & Krausse Manufacturing Co., Levee and Sidney Streets, St. Louis, Mo.
Ernest Pearce, Lohman, Mo.
J. H. Phillips, Gravois Mills, Mo.
Point Milling & Manufacturing Co., Mineral Point, Mo.
Anthony Recar, Cruise, Mo.
M. E. Rhodes, Potosi, Mo.
C. C. Rose & H. O. Hollow, Sullivan, Mo.
J. P. Rose, Richwoods, Mo.
Curtis B. Samuel, Chattanooga, Tenn.
J. E. Short, Potosi, Mo.
Stevenson & Marriott, Versailles, Mo.
A. E. Stocking & Son, De Soto, Mo.
Washington Land & Mining Co., 317 Washington Avenue, St. Louis, Mo.
L. L. Welch, Baryties, Mo.
E. P. Wells & Co., Irondale, Mo.
White & Bro., Cadet, Mo.
Ben White, Mineral Point, Mo.

NEVADA.

American Barium Co., 57 Post Street, San Francisco, Calif.
House & Mallory, Hawthorne, Nev.

NEW MEXICO.

William Petters, Las Cruces, N. Mex.

NORTH CAROLINA.

J. F. & J. B. Harrison, Hot Springs, N. C.

SOUTH CAROLINA.

Cherokee Chemical Co. (Inc.), 109 Hollingsworth Street, Baltimore, Md.

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TENNESSEE.

J. F. Doherty, Sweetwater, Tenn.
Durex Chemical Corporation, 320 Fifth Avenue, New York, N. Y.
Krebs Mining Co., Newport, Del.
H. J. Moore, Sweetwater, Tenn.
National Barium Corporation, 618 Stock Exchange Building, Philadelphia, Pa.

VIRGINIA.

Clinchfield Products Corporation, 120 Broadway, New York, N. Y.

BARYTES DEPOSITS OF THE UNITED STATES.

A brief sketch of the geology and relations of the known deposits of barytes in the United States was given by J. M. Hill in Mineral Resources for 1915 [1] and additional information about newly discovered deposits was given by Mr. Hill in the report for 1916.[2] Only the deposits not heretofore described will be mentioned here.

California.—Large deposits of barytes are reported near Afton, Baxter, and King, San Bernardino County, Calif., on the Los Angeles & Salt Lake Railroad, 50 miles east of Barstow. The deposits have been opened by Massen & Seropian, of San Francisco, who state that they intend to mine the deposit and put up a mill at Afton.

On the west coast of Catalina Island barytes is exposed in an old pit where argentiferous galena was once mined on a small scale. Galena is scattered through a matrix of tabular transparent crystalline barytes, inclosed in Tertiary volcanic rocks.

New Mexico.—A large deposit of barytes is reported near Derry, Sierra County, N. Mex., which has been opened by William Petters and Frank D. Rivera, of Las Cruces. A sample of the ore submitted to the Geological Survey is of high grade, and a sample analyzed by the New Mexico College of Agriculture contained 95.74 per cent of barium sulphate. The barytes is associated with high-grade fluorspar. A carload of the barytes was shipped to El Paso, Tex., in 1918.

Utah.—A large deposit of barytes near Lucin, Boxelder County, Utah, is reported by Frank Edison, of Lucin. A sample of the rock sent to the Geological Survey contained considerable calcite mixed with the barytes.

FOREIGN BARYTES DEPOSITS.

Germany is known to have large deposits of high-grade barytes. The better grade of ore occurs in the Harz Mountains and Thuringerwald, where there are about 150 small surface mines. Ore of poorer grade occurs in the Rhine district. Witherite, barium carbonate, is also mined in the Thuringerwald. Prior to the European war most of the crude ore used in the barium plants of the Atlantic States of the United States was imported from Germany, as were also most of the barium chemicals used in the United States. This ore was mined very cheaply, costing, according to consular reports, from $1.10 to $1.66 a ton at the mine, and crude German ore was

[1] Hill, J. M., Barytes and strontium: U. S. Geol. Survey Mineral Resources, 1915, pt. 2, pp. 166–179, 1916.
[2] Idem, 1916, pt. 2, pp. 246–250, 1918.

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quoted for delivery at New York in 1909 c. i. f. (exclusive of duty) at prices ranging from $4.50 a ton for the poorer, grayer rock to $5.50 for the pure-white mineral. As soon as trade relations are again established Germany will probably export large quantities of crude barytes and manufactured products to the United States at prices with which the American producers can not compete unless protected by a tariff.

England has fairly large deposits of barytes and workable deposits of witherite. Before the war England got most of the barytes and barium products for its own use from Germany. Its own mines supplied only a small part of the domestic needs, and no barytes and only a small quantity of witherite was exported to the United States.

Deposits of barytes are known to occur in France, Belgium, Italy, Spain, Portugal, European Turkey, Asia Minor, Tasmania, Australia, and Rhodesia, and although some of them have been extensively worked, the exports from these countries to the United States were small. Deposits in Canada have not been extensively worked, the production in 1917 being only 3,490 short tons and in 1918 640 tons. Since the end of the war, however, inquiries regarding production of barytes and markets in the United States have been received by the United States Geological Survey from several prospective producers in Canada.

Large deposits of barytes are reported at Bueycito, Oriente Province, eastern Cuba, and a test shipment is reported to have been made to lithopone factories in the United States. Samples sent to the United States Geological Survey are of excellent grade, and if the deposits are as large and accessible as reported they may prove to be an important new source for the mineral.

In South America barytes occurs as a gangue mineral in many of the metalliferous veins through the Andes, especially in Argentina, Peru, and Bolivia, but little or no barytes has been separated for shipment.

BARIUM PRODUCTS.

PRODUCTION.

The quantity of ground barytes, lithopone, and barium chemicals sold in the United States in 1918 was slightly greater than that sold in 1917, amounting to 140,675 short tons, and there has been a continued steady growth of these industries in the country since they came into prominence in 1915, as is shown in the following table:

Barium products manufactured in the United States from either domestic or imported crude ore and sold, 1915–1918, in short tons.

Product.	1915	1916	1917	1918
Ground barytes	51,557	65,440	52,694	55,086
Lithopone	46,494	51,291	63,713	62,403
Barium chemicals [a]	8,823	16,792	22,503	23,186
	106,874	133,523	138,910	140,675

[a] Barium chemicals manufactured from secondary barium products bought in open market are not included in table.

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GROUND BARYTES.

USES AND PREPARATION.

Barytes is ground for use as a white pigment, as an inert base in colored paints, and as a filler in rubber goods, linoleum, oilcloth, paper, and other articles. When bleached white and ground and reduced to a very fine powder of even texture by the flotation process, it is used largely in ready-mixed white interior paints. The opacity of barytes ground in oil is not so great as that of most other high-grade pigments, so that the covering power of the paint is reduced in proportion to the amount of ground barytes it contains. Barytes is unaffected by acids or alkalies, however, and so does not turn dark on exposure. The pigment is sometimes made to appear whiter by coloring it bluish white by precipitating with it iron sulphate from solution or by adding Prussian or ultramarine blue. Ground barytes is also used as a filler in goods that require a high calendered surface, such as playing cards, white oilcloth, and enameled paper.

In the preparation of high-grade ground barytes the ore is first ground and then bleached with dilute sulphuric acid in lead-lined vats to remove all traces of iron oxide. The German practice of bleaching ore crushed to nut size or larger is not as satisfactory as the American practice of grinding to a meal before bleaching, as it is important to remove all traces of acid if the product is to be used in colored paint or in paper. The crushed and bleached rock is then ground to a fine powder in burr mills or other suitable pulverizers to pass a 200 to 300 mesh screen. The finest grade of ground barytes is obtained by flotation on a stream of water, and this product is called "water floated."

PRODUCTION AND PRICE.

Ground barytes was made and marketed by eight firms in the United States in 1918. Although 2,400 tons more was sold in 1918 than in 1917, the quantity was not so great as that sold in 1916, which holds the record. Of the 55,000 short tons sold, 72 per cent was made in Missouri at plants in St. Louis and Mineral Point. The average price obtained for the Missouri product was $20.42 a ton. Georgia had the next larger production, which was made at Thompson, Weinman & Co.'s plant at Cartersville. Plants were in operation also in South Carolina, Virginia, Kentucky, and California. Two California factories were the only producing plants in the Western States. Although the lowest average price for the year obtained by any plant in 1918 was $12.50 a ton, the average price for the total sales for the year of all plants was $18.91.

Domestic ground barytes in bulk was quoted [1] f. o. b. at the mill at $25 a short ton from July 1 to December 1, 1918, and dropped to $22 a ton in December. Off-color ground barytes in bags in New York ranged in price from $22 to $24 a ton in the early part of the year, rose to $23 to $28 in August, and dropped again to $22 to $24 in December. Pure-white domestic floated barytes in bags was quoted in New York at $28 to $36 a ton from January to April, rose to $33 to $36 at the end of April, and remained at this figure to the

[1] Oil, Paint and Drug Reporter, vols. 93 and 94, 1918.

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middle of December, when the price fell to $32 to $34. Foreign prime white barytes ranged from $40 to $50 a ton during January, February, and March, after which there was none to be had.

The companies that reported sales of ground barytes in 1918 are as follows:

Barbour Chemical Works, 707 West Coast Life Building, San Francisco, Calif.; plant at Oakland, Calif.

Central Pigment Co., Strand Building, Forty-seventh Street and Broadway, New York, N. Y.; plant at Nicholasville, Ky.

Cherokee Chemical Co., 109 Hollingsworth Street, Baltimore, Md.; plant at Kings Creek, S. C.

J. C. Finck Mineral & Milling Co., 101 Barton Street, St. Louis, Mo.; plant at St. Louis.

Nulsen, Klein & Krausse Manufacturing Co., Levee and Sidney streets, St. Louis, Mo.; plants at St. Louis and at Lynchburg, Va.

Point Milling & Manufacturing Co., Mineral Point, Mo.; plant at Mineral Point, Mo.

Thompson, Weinman & Co., 100 William Street, New York, N. Y.; plant at Cartersville, Ga.

West Coast Kalsomine Co., West Berkeley, Calif.

LITHOPONE.

USES AND PREPARATION.

Lithopone is a valuable pigment manufactured from barytes and zinc. The process of manufacture is in general as follows: Barytes is chemically treated, and a solution of barium sulphide is obtained. Zinc ore, zinc scrap, or more frequently zinc skimmings and dross from smelters and refineries, is chemically treated, and a solution of zinc sulphate is obtained, which must be purified by the removal of all traces of cadmium, iron, or other metals. These solutions are heated and mixed in a large tank, and the chemical reaction that takes place forms an insoluble precipitate composed of 68 to 70 per cent of barium sulphate and 30 to 32 per cent of zinc sulphide intimately mixed. After the precipitate is dried in filter presses and driers, it is heated red-hot in a furnace and then quenched in water. This is an essential part of the process, for it changes the constitution of the powder by making it more opaque and white, and the grade of the product depends largely on the success of this delicate process.

To insure the complete chemical reaction in the process of precipitation, an excess of barium sulphide, which is both cheap and soluble, is maintained. But this excess must be completely washed out to make the product satisfactory, and this purification is completed in the final grinding in water of the quenched product and floating it.

In the process of drying and heating, some of the zinc sulphide is changed to oxide, so that from 1 to 10 per cent of the finished compound is zinc oxide. Some of the compounds here included under lithopone may have a slightly different composition, their exact contents being kept a trade secret, but they are all believed to be barium-zinc compounds of about the same composition. Lithopone is also mixed with zinc oxide, flake white (lead), or other white pigments in various proportions as pigments, and some of these mixtures that are on the market are also probably included under this heading.

Lithopone is primarily an interior pigment, finding its greatest usefulness as a flat wall paint. Dull-finish wall paint is coming more and more into use on interior walls of buildings and is replacing wall paper in most institutions, such as hotels, hospitals, schools, libraries

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and factories, as well as homes, especially where indirect lighting is installed. Lithopone is equal or superior to zinc oxide for this purpose, but for paints having a glazed finish, especially enamels, zinc oxide is more satisfactory. Lithopone can be laid on smoothly though not so smoothly as zinc oxide, and in this respect it is more satisfactory than white lead, which shows brush marks and must therefore be stippled in interior wall work.

Lithopone has many advantages over both white lead and zinc oxide. It is whiter than white lead and equal in whiteness to the best grade of French process zinc oxide. It is not affected by sulphur or hydrogen sulphide as white lead is, and it is nonpoisonous, whereas lead paint is so poisonous that in France and some other countries its use as a paint is prohibited. Lithopone does not blacken by combining with lead contained in pigments or driers with which it is mixed. In opacity or hiding power the pigment is superior to white lead and about equal to zinc oxide, but when it is used in a mixed paint this claim can not be sustained, as the larger quantity of oil used with lithopone reduces its covering power.

As an exterior paint lithopone does not at present give complete satisfaction when used alone, as in direct sunlight it is likely to discolor and turn gray, and its surface becomes chalky and checked. It is claimed that by mixing with lithopone small quantities of other white pigments, such as zinc oxide and whiting (calcium carbonate or chalk), these objections have been removed. Such pigments made in part of lithopone, which are said to be eminently satisfactory for exterior use, are on the market. A mixture of 60 per cent of lithopone, 20 per cent of zinc oxide, and 20 per cent of whiting ground in pure linseed oil has been recommended for exterior use.

Lithopone and allied pigments are sold under many trade names, nearly every maker having a distinctive name for his own product and claiming for it exceptional qualities. Some of the best known trade names in use are Beckton white, Ponolith, Zincolith lithopone, Sterling lithopone, Marbon white, and Fulton white. Some lithopone is still imported under the old name "zinc sulphide white." Various grades of lithopone are recognized in the trade. Green seal is the best and the nearest equivalent of French process zinc oxide; red seal, blue seal, and yellow seal are relatively poorer grades. The poorer grades are produced by mechanically mixing ground barytes or blanc fixe with lithopone, resulting approximately in the following proportions of zinc sulphide and barium sulphate:

	Zinc sulphide.	Barium sulphate.
Green seal	1 part	2 parts.
Red seal	1 part	3 parts.
Blue seal	1 part	4 parts.
Yellow seal	1 part	5 parts.

PRODUCTION AND PRICE.

Lithopone was manufactured and sold by nine companies in the United States in 1918. Although the quantity sold in 1918 was 1,300 tons less than that sold in 1917, it was considerably greater than that sold in 1916 and about 16,000 tons more than was sold in 1915.

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This increase was due largely to the great demand for the pigment as a flat wall paint. Of the 62,403 short tons put on the market, about two-thirds came from plants in New Jersey and Pennsylvania. Two plants in Delaware and Maryland also produced considerable lithopone. The quantity marketed from the seven plants in the four adjoining States centering around Philadelphia amounted to nearly 52,000 short tons, a decrease of about 6,000 tons from the output in 1917, the falling off being chiefly in Delaware. Illinois, with two producing plants, also had a large production and marketed 2,500 tons more than it did in 1917. Missouri, the source of most of the ore in the central part of the country, had a relatively small production of lithopone, which was, however, a good start for an industry only two years old in the State.

The average price obtained for all the lithopone made and sold in 1918 was $126.97 a short ton, or 6⅓ cents a pound, as compared with $116.25, or 5.8 cents a pound, in 1917. The highest average price for the year received by any one company was $140 a ton. The wholesale prices quoted in New York [1] for lithopone in bags ranged from 6½ to 7 cents a pound in the early part of 1918, rose to 8 to 8½ cents in September, and at the end of November fell again to 7½ to 8½ cents. The prevailing prices in 1917 were somewhat lower, ranging from 6¼ to 7 cents.

The following manufacturers reported production and sale of lithopone, or barite-zinc compounds of similar composition and use, in 1918:

Butterworth-Judson Corporation, 61 Broadway, New York, N. Y.; plant at Newark, N. J.
Chemical Pigments Corporation, 825 Stock Exchange Building, Philadelphia, Pa.; plant at St. Helena, Md.
E. I. Du Pont de Nemours & Co., Wilmington, Del.; plants at Camden and Newark, N. J, and Philadelphia, Pa.
Grasselli Chemical Co., Cleveland, Ohio; plant at Grasselli, N, J.
Krebs Pigment & Chemical Co., Newport, Del.; plant at Newport.
Midland Chemical Co., 80 East Jackson Boulevard, Chicago, Ill.; plant at Argo, Ill.
Mineral Refining & Chemical Corporation, Carondelet Station, St. Louis, Mo.; plant at St. Louis.
New Jersey Zinc Co., 55 Wall Street, New York, N. Y.; plant at Palmerton, Pa.
Sherwin-Williams Co., 601 Canal Road, Cleveland, Ohio; plant at Kensington, Ill.

BARIUM CHEMICALS.

Under barium chemicals are included all manufactured chemical compounds that contain barium, and this classification logically includes lithopone, but as the manufacture of lithopone is an industry by itself entirely independent of the barium-chemical industry, it has been separately treated. Many barium chemicals are secondary compounds made from other barium chemicals and not directly from barytes or other barium minerals. As this report deals with barytes and its immediately derived products, only those chemicals that are made directly from barytes or those that are manufactured in the same plant from primary salts of barium so made will be described here. Chemicals that are made from barium chemicals bought in the open market from other factories will therefore not be described and have not been included in the production tables.

[1] Oil, Paint, and Drug Reporter, vols. 93 and 94. 1918.

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METHODS OF MANUFACTURE AND USE.

The methods of manufacture of the barium chemicals here described have been briefly given by J. M. Hill.[1]

Most barium chemicals have a wide variety of use.

Barium binoxide or peroxide (BaO_2) is used largely in the manufacture of hydrogen peroxide, in which blanc fixe is a by-product. It is used also to some extent in the preparation of oxygen, for it has the property of readily giving off oxygen under certain conditions and of taking up oxygen again under other conditions. In a similar capacity it is used as a bleach for straw hats and blankets, Barium monoxide (BaO) is an intermediate compound from which binoxide and hydroxide are made.

Barium carbonate is used chiefly in the brick industry to produce an even color in brick and terra cotta and to prevent a white efflorescence on exposed surfaces. It is being used more and more in steel manufacture in making case-carbonized steel. It is used also in the manufacture of optical glass, flat wall paints, and rat poisons, and to glaze earthenware. It is also a water softener. As a paint component, its hiding quality is considered to be intermediate between lithopone and blanc fixe. When mixed with zinc oxide it is claimed by some to equal a mixture of white lead and zinc oxide. It is a chemical from which many other secondary barium chemicals are made.

Barium chlorate is used in pyrotechnics and to some extent in explosives.

Barium chloride is used largely in the purification of table salt, removing all traces of magnesium and sodium sulphates. It is also a mordant in the precipitation of dyes on inert bases, such as blanc fixe and aluminum hydrate, to form lake pigments. Its uses, however, are many and cover most of those of barium carbonate, including the prevention of efflorescence on bricks. It is a chemical from which many other barium compounds are made, and during the European war it entered into the manufacture of chemicals for war purposes, blanc fixe being a by-product in the process. Barium chloride and calcium chloride are employed in the manufacture of hard lead as a substitute for antimonial lead in some of its many uses, including shrapnel bullets. In this process barium and calcium are alloyed with the lead when in a molten state by electric currents. The resulting alloy is heavier and less brittle than antimonial lead, and one of its chief uses is in making thrust washers in automobile differential gears.

There are many uses to which barium hydroxide can be applied. It is employed in the refining of sugar in France, but because of its poisonous nature it is not generally used for this purpose.

Barium nitrate is used largely in the preparation of green fire or Bengal fire in pyrotechnics, in green signal lights, and in powders to give an artificial driftwood blaze to log fires in open fireplaces. It is also used in the manufacture of tonite, an explosive made of guncotton and barium nitrate, and of saxifragine, made of charcoal and barium nitrate.

Chemically precipitated barium sulphate, sold on the market as blanc fixe, permanent white, or constant white, is a pigment of

[1] Hill, J. M., Barytes and strontium, U. S. Geol. Survey Mineral Resources, 1915, pt. 2, pp. 182–184, 1916.

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superior quality. It is finer, more impalpable, and of more even grain than ground water-floated barytes, which has the same chemical composition, but is crystalline instead of amorphous. It therefore has greater opacity than ground barytes, is whiter, and does not settle in the oil vehicle as badly as barytes. Although used to considerable extent in flat white paints, it is largely used as the inert base in the manufacture of organic lake pigments and colored lithographic inks. It is also used in the manufacture of highly glazed white paper, oilcloth, linoleum, rubber goods, and putty. It is largely a by-product of the manufacture of other chemicals.

Barium sulphide when refined is used as a laboratory reagent. It sometimes enters the market in the crude form, called black ash, resulting from calcining barytes with coal in the proportion of 4 to 1, which is the first step in the process of making most other barium compounds. Barium sulphide is mixed with phosphate tailings from iron concentrating plants and finely ground, and the mixture is sold as a fertilizer called "barium phosphate." When used on fields the barium sulphide is said to act on the calcium phosphate in the mixture and set free phosphoric acid.

PRODUCTION.

The manufacture of barium chemicals in the United States, which practically began in 1915 with an output of 8,823 tons, was nearly doubled in 1916 and nearly trebled in 1917. The quantity marketed in 1918 was 23,186 short tons, an increase of 683 tons over that sold in 1917.

Barium chemicals were made either directly or indirectly from crude barytes in 1918 in 11 plants in the United States, two of which are on the Pacific coast (in California), three on the Atlantic seaboard (in New York and New Jersey), and the rest in Illinois, Ohio, Tennessee, and West Virginia.

The Durex Chemical Co., of New York, with plants at Long Island City, N. Y., and Sweetwater, Tenn., manufactured and sold five of the seven chemicals here enumerated and leads in total output. The Rollin Chemical Co., of Charleston, W. Va., which stands next in the quantity produced, made six of the seven products. The Clinchfield Products Corporation, of New York, with plant at Johnson City, Tenn., was the only other large producer of barium chemicals.

Barium chemicals of domestic manufacture sold, 1915–1918.

Chemical.	1915	1916	1917	1918
	Quantity (short tons).	Quantity (short tons).	Quantity (short tons).	Quantity (short tons).
Barium binoxide	(a)	1,980	(a)	(a)
Barium carbonate	2,746	6,844	8,238	7,661
Barium chloride	2,106	3,643	4,870	4,530
Barium nitrate	971	446	155	(a)
Barium sulphate (blanc fixe)	(a)	3,337	6,314	9,522
Other barium chemicals b	3,000	542	2,916	1,473
	8,823	16,792	22,503	23,186

a Included under "Other barium chemicals."
b Includes, 1915: Binoxide, hydroxide, sulphate, sulphide, and other barium chemicals not specified; 1916: Hydroxide and sulphide; 1917: Binoxide, hydroxide, and sulphide; 1918: Binoxide, hydroxide, nitrate, and sulphide.

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Barium binoxide manufactured from barytes was marketed by only two firms in 1918. One other plant reported the manufacture of binoxide from barium salts purchased in the open market, and its product is not included in the preceding table of statistics. The quantity reported as sold, including the product of the latter plant, was less than 1,250 short tons. The average price obtained was $418 a ton.

Barium carbonate was manufactured and sold by five firms in the United States, which put on the market 7,661 tons, as compared with 8,238 tons in 1917. About 88 per cent of this output was produced by three firms in the eastern part of the country. The average price obtained was $48.18 a ton.

Barium chloride was marketed by eight firms in 1918, two of which are in California, two in Illinois, and the rest in the eastern part of the country, and which produced 4,530 tons, as compared with 4,870 tons in 1917. The average price received was $71.62 a ton.

Barium hydroxide was manufactured by only one firm using crude ore in the United States in 1918, and the quantity sold was very small. Likewise only small quantities of barium nitrate and barium sulphide were made in two plants using crude ore.

Barium sulphate or blanc fixe was manufactured and sold in 1918, by five firms, all in the eastern part of the United States. The quantity marketed by them, 9,522 tons, showed an increase of more than 50 per cent over that of 1917, which was 6,314 tons. Most of this was produced in plants in New York, Tennessee, and West Virginia, partly as a by-product in the manufacture of other chemicals. The average price obtained was $44.78 a ton.

In comparison with the prices given above received at the plants for barium chemicals, the following table gives the range in wholesale market price in New York during 1918:

Monthly range of wholesale market prices in New York for barium chemicals, 1918.[a]

Month.	Blanc fixe (barium sulphate) dry in barrels.	Barium chlorate.	Barium chloride.		Barium dioxide.	Barium nitrate.
			Off color.	White crystals.		
	Per pound.	*Per pound.*	*Per short ton.*	*Per short ton.*	*Per pound.*	*Per pound.*
January	$0.03¾–$0.04	[b]$0.50–$0.60	$65.00–$90.00		[b]$0.38	$0.11 –$0.14
February	.03¾– .05½	[b].50– .60	65.00– 90.00		[b].38	.12 – .14
March	.04½– .05½	[b].50– .60	65.00– 85.00		[b].38	.12 – .14
April	.04½– .05½	.50– .60	65.00–100.00		[b].38	.12 – .14
May	.05 – .06	.50– .60	$65.00–$70.00	$95.00–$100.00	.25–$0.38	.12 – .14
June	.05½– .06	.50– .60	65.00– 70.00	95.00– 100.00	.25– .30	.12 – .14
July	.05½– .06	.50– .60	65.00– 70.00	95.00– 100.00	.25– .30	.12 – .14
August	.05½– .06	.50– .60	65.00– 70.00	85.00– 100.00	.25– .30	.12 – .14
September	.05½– .06	.50– .60	65.00– 70.00	85.00– 100.00	.25– .30	.12 – .14
October	.05½– .06	.50– .60	65.00– 70.00	85.00– 100.00	.25– .30	.12 – .14
November	.05½– .06	.50– .60	65.00– 70.00	85.00– 100.00	.25– .30	.12 – .14
December	.05½– .06	.50– .60	65.00– 80.00	85.00– 100.00	.25– .30	.11½– .12
Year	.03¾– .06	.50– .60	65.00– 80.00	85.00– 100.00	.25– .38	.11 – .14

[a] Oil, Paint, and Drug Reporter, vols. 93 and 94, 1918. [b] Nominal.

The increase in price of blanc fixe from 3¾ to 4 cents a pound, approximately the price that prevailed during 1917, to 5½ to 6 cents in June 1918 was apparently due to increased demand for the product, and this may have been in part the cause of the large increase of production of this compound during the year. Barium nitrate,

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on the other hand, declined from the price of 15 to 16 cents a pound early in 1917 to between 11 and 14 cents, which prevailed during the whole of 1918. This decline in price and the corresponding decline in output were probably due to decreased demand for the material for war purposes.

The following domestic manufacturers reported that they had made barium chemicals directly or indirectly from crude barytes during 1918:

American Barium Co., 57 Post Street, San Francisco, Calif.; plant at South San Francisco.

Ault & Wiborg Co., Cincinnati, Ohio; plant at St. Barnard, Ohio.

Barbour Chemical Works, 707 American National Bank Building, San Francisco, Calif.; plant at Melrose, Calif.

Chicago Copper & Chemical Co., 111 West Jackson Boulevard, Chicago, Ill.; plant at Blue Island, Ill.

Clinchfield Products Corporation, 120 Broadway, New York, N. Y.; plant at Johnson City, Tenn.

Durex Chemical Co., 320 Fifth Avenue, New York, N. Y.; plants at Long Island City, N. Y., and Sweetwater, Tenn.

Grasselli Chemical Co., Cleveland, Ohio; plant at Grasselli, N. J.

Midland Chemical Co., 80 East Jackson Boulevard, Chicago, Ill.; plant at Argo, Ill.

Oakland Chemical Co., 10 Astor Place, New York, N. Y.; plant at New York.

Rollin Chemical Co., Charleston, W. Va.; plant at Charleston.

IMPORTS.

The value of imports of barium products, including ground witherite or natural barium carbonate, declined from $459,841 in 1916 to $59,669 in 1917, and shrank still further to only $15,127 in 1918. This reduction was due to the fact that there were no ground barytes nor barium chemicals imported in 1918 and only a little lithopone imported under the name "zinc sulphide white," so that the usual quantity of ground and refined natural barium carbonate, or witherite, which is duty free, formed the bulk of the imports of barium products. Although the value of the barium carbonate imported in 1918 was approximately the same as the average for the preceding five years, it was somewhat less than the value of the imports in 1917 and in 1916. Since the term "lithopone" was introduced in 1913 it has found general use and has almost supplanted the older term "zinc sulphide white."

Value of barium products imported and entered for consumption in the United States, 1912–1918.[a]

Product.	1912	1913	1914	1915	1916	1917	1918
Manufactured barytes (ground and refined)	$26,848	$38,155	$30,483	$10,736	$2,072	$1,743	.....
Lithopone	.....	45,624	259,710	137,816	405,730	29,199	.....
Zinc sulphide white (lithopone)	153,308	107,356	18,112	6,751	8,862	6,519	$998
Barium carbonate:							
Natural (witherite, ground and refined)	15,777	13,116	8,084	12,165	18,169	17,321	14,134
Manufactured (chemically prepared)	9,938	38,949	28,221	2,786	.....	1,554	.....
Barium binoxide	252,320	239,000	332,709	218,776	6,590	.....	.....
Barium chloride	27,655	37,620	68,866	31,295	608	.....	.....
Blanc fixe or artificial barium sulphate	70,327	62,785	32,619	18,501	17,810	3,333	.....
	556,168	582,605	778,804	438,826	459,841	59,669	15,127

[a] Compiled from reports of the Bureau of Foreign and Domestic Commerce, Department of Commerce.

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PETROLEUM.

By E. Russell Lloyd.

INTRODUCTION.

GENERAL CONDITIONS.

The year 1918 was one of exceptional interest in the petroleum industry as well as in all other great industries. It witnessed the organization of the industry on a war basis under the direction of the United States Fuel Administration, a quickening of activity in all phases of the industry, and an active coordination of all its branches in a complete and unified organization for the one purpose of supplying petroleum products for the necessary operations of the United States and the Allied nations in winning the war. This organization was accomplished largely by the industry itself through the National Petroleum War Service Committee working in close harmony with the oil division of the United States Fuel Administration. The result was obtained with a minimum of Government control, and the soundness of the principles upon which the organization was based was proved not only by the successful accomplishment of the immediate objective but also by the fact that the transition from a war to a peace basis required a minimum of adjustment.

On January 10, 1918, M. L. Requa was appointed director of the oil division of the United States Fuel Administration and immediately took active steps to organize his division. Mr. Requa promptly relieved the uncertainty in the minds of many oil operators and distributors, who feared that the industry might be taken over as a whole by the Government, by the timely announcement that the industry would be called upon to cooperate with the Government in every way possible, but that Government control and Government supervision would be kept at a minimum. Organization of the petroleum industry was effected through the National Petroleum War Service Committee, of which A. C. Bedford was chairman. A proclamation by President Wilson, effective on January 11, 1918, placed the manufacturing and distribution of fuel oil under Government control by means of a leasing system. This control extended to all firms marketing more than 100,000 barrels of fuel oil a year.

Mr. Requa found that one of the greatest problems before the oil division of the Fuel Administration was to secure adequate transportation, and as a result of the intensive demand for petroleum products an order was issued from the office of the Director General of Railroads, effective on January 31, exempting petroleum and petroleum products from embargoes on all railroads in the country.

Early in the year the price of the Pennsylvania grade of crude oil rose from $3.75 to $4 a barrel and prices of other grades of oil throughout the country were advanced in corresponding ratio. When further advances in the prices of crude were threatened Mr. Requa wrote to Chairman Bedford of the National Petroleum War Service Committee

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that in his opinion there was no justification for an advance in the price of crude oil at that time and that the oil division would expect full cooperation from the producers in an endeavor to maintain the existing prices for crude oil as maximum prices. The Petroleum War Service Committee reported a proposed method for stabilizing the prices of crude and for establishing definite and fixed differentials for various grades of crude. This plan was submitted on August 6, 1918, and its adoption was largely responsible for the maintenance of prices of crude oil at a constant level during the remainder of the year.

In 1918 interest was centered primarily on the problem of increasing the production to meet the enormously increased requirements for petroleum products. The results were highly creditable and showed marked increase in production despite increasing difficulties—difficulties not only of an abnormal nature caused largely by war conditions but also the inherent difficulties of finding new pools and of overcoming the increase in average depth to which it has become necessary to drill. The resultant increase in production, although not so great as in 1917, was comparable to the increase in other recent years but failed by a wide margin to keep pace with the demands. Since 1915 the quantity of domestic petroleum consumed in and exported from the United States has exceeded the domestic production by an increasing quantity.

Much of the deficit in our domestic supply in 1918 was made good from the prolific Mexican fields. Here again difficulties of the gravest nature threatened the supply. The unsettled condition of the country and the hostile attitude of the Mexican Government rendered extremely hazardous both the lives and the property of American citizens operating in that country. Despite the drawbacks, the Mexican industry stood ready to furnish an abundant supply of petroleum, but serious impediments resulted from a lack of tanker facilities incident to the prime necessity of diverting a considerable proportion of the tanker fleet to the purpose of carrying war supplies to Europe.

The industry was confronted by numerous difficulties during the year. Weather conditions in the earlier months were exceptionally severe, resulting in a marked curtailment of production; insufficient transportation facilities proved a very serious handicap; shortage of supplies manifested itself particularly in its effect on production; and the drilling of new wells was hindered by lack of drilling rigs and casing. This scarcity of material also delayed the extension of pipe lines to the newer fields of northern Texas. The lack of skilled labor became a menace toward the end of the summer, and the epidemic of influenza seriously hampered the industry in the fall. Despite these obstructions the industry made rapid strides forward, not only in the opening of new fields but particularly in the intensive development of pools already discovered.

SIGNIFICANT DEVELOPMENTS.

The one region of outstanding interest in 1918 was northern central Texas, in which development was focused in two districts—the deep sand areas of Eastland, Stephens, and northern Comanche counties, and the comparatively shallow prolific pool at Burkburnett, in Wichita County. The campaign of wildcat drilling radiating from

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these centers extended over a large part of western Texas before the end of 1918. Second in importance to the northern Texas development only was the intensive development of the Pine Island pool in Caddo Parish, northern Louisiana, the development of a number of prolific shallow pools in Kentucky, and the development of the prolific Montebello and Casmalia pools in California and the Big Muddy pool in Wyoming. Important discoveries of new pools included the Youngstown pool, Okmulgee County, Okla.; new territory in Stephens County, Okla.; important extensions of the deep sand areas of northern Texas; the Burkburnett shallow pool, Wichita County, Tex.; new and prolific domes at West Columbia in Brazoria County and at Hull in Liberty County, Tex.; the Homer field in Claiborne Parish, La.; the important Lance Creek pool in Niobrara County, Wyo.; and a very significant find in the Elk Hills district in San Joaquin Valley, Calif.

ACKNOWLEDGMENTS.

This report is designed as a record primarily of the producing branch of the domestic petroleum industry, but includes also figures concerning the consumption of crude oil and some data on the production of petroleum in foreign countries. The present chapter is the thirty-seventh in the series of statistical records of the petroleum industry issued by the United States Geological Survey since its organization and follows very closely the form of previous chapters. The statistical tables have been prepared by Misses A. B. Coons and M. N. Schellenger, of the United States Geological Survey, with the exception of those relating to imports and exports, which were compiled from the records of the Bureau of Foreign and Domestic Commerce, Department of Commerce, by J. A. Dorsey, also of the Geological Survey. The writer is indebted to Mr. Walter A. English for the description of developments in California in 1918. Valuable suggestions have been received from Mr. Frank W. De Wolfe, State geologist of Illinois, and from Prof. J. A. Bownocker, State geologist of Ohio, concerning operations in those States.

The tables on production are compiled from data furnished by producing, transporting, and refining companies throughout the United States. It is only through the continued and active cooperation of those engaged in the industry that these reports are possible.

PRODUCTION.

GENERAL STATEMENT.

The term "production" as used in this report has the same meaning as "marketed production" in the petroleum statistical reports for 1914, 1915, and 1916, and as "petroleum marketed" in the report for 1917, published as chapters of the volumes on Mineral Resources of the United States. The term "marketed production" has caused misunderstanding and has been interpreted to mean deliveries to refineries and to other consumers. The quantity of crude petroleum produced in the United States in 1918, as shown by runs to pipe lines from field sources and by shipments from wells by tank cars or wagons, including oil used for field development, aggregated 355,927,716 barrels of 42 gallons each. This established a new record

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for output of petroleum in this country that is more than 6 per cent greater than the former maximum yield of 335,315,601 barrels, attained in 1917.

The average price received for this oil at the wells was $1.978 a barrel, and the total market value of the output was $703,943,961, a gain of 42 cents in average unit price and of $181,308,748, or 35 per cent, in gross market value, compared with 1917.

The figures of production given above are in excess of the actual amount of petroleum taken from the ground during 1918 by the net decrease during the year of stocks of crude oil held by producers and not delivered to marketing companies. According to the best available data, this net decrease amounted to 6,158,714 barrels. Deduction of this quantity from the figures of production given above indicates that approximately 349,769,000 barrels of petroleum was taken from the ground in 1918.

STATISTICS.

Petroleum produced in the United States in 1917 and 1918, by months, in barrels of 42 gallons.

[Segregation by months approximate.

Month.	1917		1918	
	Quantity.	Daily average.	Quantity.	Daily average.
	Barrels.	*Barrels.*	*Barrels.*	*Barrels.*
January	26,333,171	849,457	27,330,178	881,619
February	23,696,107	846,290	25,855,974	923,428
March	27,979,149	902,553	29,664,706	956,926
April	27,104,844	903,495	28,964,963	965,499
May	27,616,740	890,863	30,389,808	980,316
June	27,431,228	914,374	29,853,850	995,128
July	29,079,301	938,042	31,816,744	1,026,347
August	29,642,662	956,215	30,645,897	988,577
September	29,670,770	989,026	30,436,460	1,014,548
October	30,418,432	981,240	31,257,761	1,008,315
November	28,716,464	957,215	29,914,386	997,146
December	27,626,733	891,185	29,796,999	961,194
	335,315,601	918,673	355,927,716	975,144

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Petroleum produced in the United States in 1859-1918, in barrels of 42 gallons.

Year.	Pennsylvania and New York.	Ohio.	West Virginia.	California.	Kentucky and Tennessee.	Colorado.	Indiana.	Illinois.	Kansas.
	Barrels.	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*
Prior to 1908	687,425,409	366,250,105	185,039,718	201,965,825	5,276,578	8,874,285	90,127,511	28,866,683	[a] 42,357,150
1908	10,584,453	10,358,797	9,528,176	44,864,737	[c] 727,767	379,553	3,283,629	33,688,238	1,801,781
1909	10,434,300	10,632,793	10,746,092	55,471,601	[c] 639,016	310,361	2,296,066	30,898,339	1,263,764
1910	9,848,500	9,916,370	11,753,071	73,010,560	[c] 468,774	239,794	2,150,725	33,143,362	1,128,668
1911	9,200,673	8,817,112	9,795,464	81,134,391	[c] 472,458	226,926	1,695,289	31,317,038	1,278,319
1912	8,712,076	[g] 8,969,007	12,128,962	[h] 87,272,598	[c] 484,368	206,052	970,009	28,601,308	1,592,796
1913	8,865,493	8,781,468	11,567,299	97,788,525	[c] 524,568	188,799	956,095	28,893,899	2,375,029
1914	9,109,309	8,536,362	9,680,033	99,775,327	[c] 502,441	222,773	1,335,456	21,919,749	3,103,585
1915	8,726,483	7,825,326	9,264,798	86,591,535	[c] 437,274	208,475	875,758	19,041,695	2,323,487
1916	8,466,481	7,744,511	8,731,184	90,951,936	1,203,246	197,235	769,036	17,714,235	8,738,077
1917	8,612,885	7,750,540	8,379,285	93,877,549	3,100,356	121,231	759,432	15,776,860	36,536,125
1918	8,216,655	7,285,005	7,866,628	97,531,997	4,376,342	143,286	877,558	13,366,974	45,451,017
	788,202,717	463,367,386	294,474,710	1,110,226,676	18,213,188	11,319,370	106,105,584	298,225,380	148,450,298

Year.	Texas.	Oklahoma.	Wyoming.	Louisiana.	Montana.	Other.	United States.	Total value.
	Barrels.	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	
Prior to 1908	117,819,991	[b] 45,084,441	[e] 85,785	27,413,511	.....	[d] 21,471	1,806,608,463	$1,657,113,275
1908	11,206,464	45,798,765	[f] 17,775	5,788,874	.....	[d] 15,246	178,527,355	129,079,184
1909	9,534,467	47,899,218	[f] 20,056	3,059,531	.....	[d] 5,750	183,170,874	128,328,487
1910	8,899,266	52,028,718	[f] 115,490	6,841,395	.....	[d] 3,615	209,557,248	127,899,688
1911	9,526,474	56,099,637	[f] 188,695	10,720,420	.....	[d] 7,995	220,449,391	134,044,762
1912	11,735,057	51,427,071	1,572,306	9,263,439	.....	.....	222,935,044	164,213,247
1913	15,009,478	63,579,384	2,406,562	12,496,828	.....	[i] 10,843	248,446,230	237,121,388
1914	20,068,184	73,631,724	3,560,375	14,309,435	.....	[j] 7,792	265,762,535	214,125,215
1915	24,942,701	97,915,243	4,245,525	18,191,539	.....	[j] 14,265	288,104,104	179,462,990
1916	27,644,605	107,071,715	6,234,137	15,248,138	44,917	[j] 7,705	300,767,158	330,899,868
1917	32,413,287	107,507,471	8,978,680	11,392,201	99,399	[k] 10,300	335,315,601	522,635,213
1918	38,750,031	103,347,070	12,596,287	16,042,600	69,323	[k] 7,943	355,927,716	703,943,961
	327,550,005	851,320,457	40,019,573	150,769,911	213,639	112,925	4,608,571,719	4,528,867,168

[a] Includes Oklahoma in 1905 and 1906.
[b] Production for 1905 and 1906 included in Kansas.
[c] Includes Utah in 1907.
[d] Michigan and Missouri.
[e] No production recorded for Tennessee.
[f] Includes Utah.
[g] Includes Michigan.
[h] Includes Alaska.
[i] Alaska, Michigan, Missouri, and New Mexico.
[j] Alaska, Michigan, and Missouri.
[k] Alaska and Michigan.

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Petroleum produced in the United States in 1917 and 1918.

State.	Quantity.				Value.		Average price per barrel.	
	1917 (barrels).	1918 (barrels).	Increase or decrease.		1917	1918	1917	1918
			Barrels.	Per cent.				
California	93,877,549	97,531,997	+ 3,654,448	+ 3.89	$86,161,764	$118,770,790	$0.918	$1.218
Colorado	121,231	143,286	+ 22,055	+18.19	128,100	188,472	1.057	1.315
Illinois	15,776,880	13,365,974	− 2,410,906	−15.28	31,358,069	31,230,000	1.988	2.337
Indiana	759,432	877,558	+ 118,126	+15.55	1,470,548	2,028,129	1.936	2.311
Kansas	36,536,125	45,451,017	+ 8,914,892	+24.40	67,120,573	100,546,302	1.837	2.212
Kentucky	3,088,160	4,367,968	+ 1,279,808	+41.44	7,033,714	11,287,162	2.278	2.584
Louisiana	11,392,201	16,042,600	+ 4,650,399	+40.82	17,224,602	27,535,060	1.600	1.716
Montana	99,399	69,323	− 30,076	−30.26	146,272	125,328	1.472	1.815
New York	879,685	808,843	− 70,842	− 8.05	2,850,378	3,307,314	3.240	4.089
Ohio	7,750,540	7,285,005	− 465,535	− 6.01	21,104,483	23,465,197	2.723	3.221
Oklahoma	107,507,471	103,347,070	− 4,160,401	− 3.87	181,646,981	231,136,305	1.690	2.237
Pennsylvania	7,733,200	7,407,812	− 325,388	− 4.21	25,154,290	29,606,079	3.253	3.997
Tennessee	12,196	8,374	− 3,822	−31.34	28,448	21,704	2.333	2.592
Texas	32,413,287	38,750,031	+ 6,336,744	+19.55	42,891,555	74,867,537	1.323	1.932
West Virginia	8,379,235	7,866,628	− 512,657	− 6.12	27,246,960	31,652,018	3.252	4.024
Wyoming	8,978,690	12,596,287	+ 3,617,607	+40.29	11,047,876	18,159,778	1.230	1.442
Other	a10,300	a7,943	− 2,357	−22.88	a20,600	a15,986	2.000	2.013
	335,315,601	355,927,716	+20,612,115	+ 6.15	522,635,213	708,943,961	1.559	1.978

aAlaska and Michigan.

RANK OF PRODUCING STATES.

Changes in rank of producing States based on the quantity produced were not important in 1918 as compared with 1917. The position of the first four States, Oklahoma, California, Kansas, and

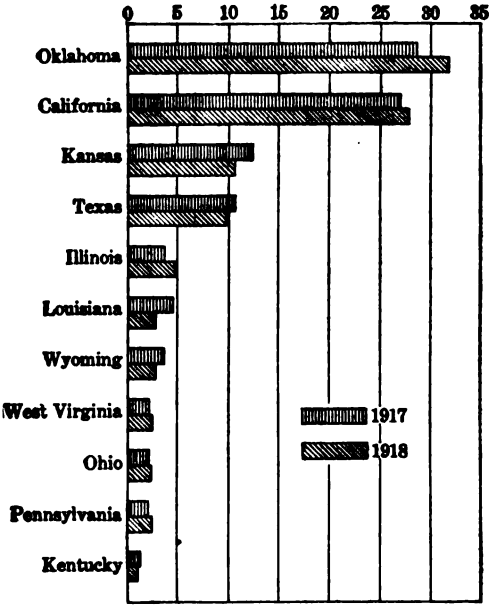

FIGURE 100.—Percentage of total quantity of petroleum produced in the United States in 1917 and 1918, by States.

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Texas, remained unchanged; Louisiana advanced from sixth to fifth place, displacing Illinois; Pennsylvania advanced from tenth to ninth place, displacing Ohio; and Indiana advanced from thirteenth to twelfth place, displacing New York.

Changes in rank based on the value of the production were similarly unimportant.

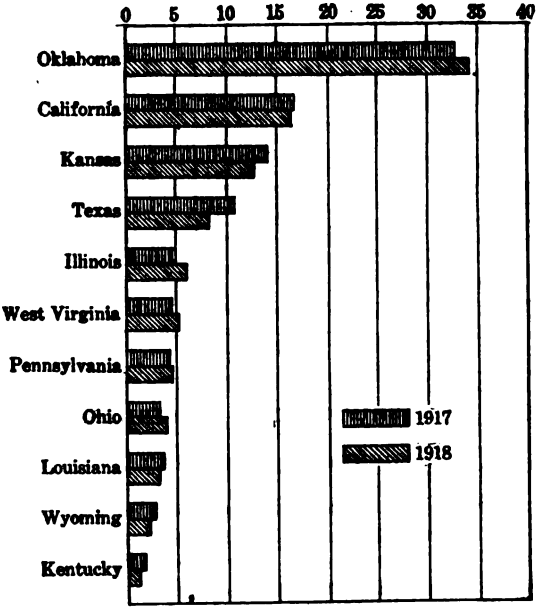

FIGURE 101.—Percentage of total value of petroleum produced in the United States in 1917 and 1918, by States.

Rank of petroleum-producing States in 1917 and 1918.

By quantity.

State.	1917			1918		
	Rank.	Output (barrels).	Per-centage.	Rank.	Output (barrels).	Per-centage.
Oklahoma	1	107,507,471	32.06	1	103,347,070	29.03
California	2	93,877,549	28.00	2	97,531,997	27.40
Kansas	3	36,536,125	10.90	3	45,451,017	12.77
Texas	4	32,413,287	9.67	4	38,750,031	10.89
Illinois	5	15,776,860	4.70	6	13,365,974	3.76
Louisiana	6	11,392,201	3.40	5	16,042,600	4.51
Wyoming	7	8,978,680	2.68	7	12,596,287	3.54
West Virginia	8	8,379,285	2.50	8	7,866,628	2.21
Ohio	9	7,750,540	2.31	10	7,285,005	2.05
Pennsylvania	10	7,733,200	2.30	9	7,407,812	2.08
Kentucky	11	3,088,160	.92	11	4,367,968	1.23
New York	12	879,685	.26	13	808,843	.22
Indiana	13	759,432	.23	12	877,558	.25
Colorado	14	121,231	.04	14	143,286	.04
Montana	15	99,399	.02	15	69,323	
Tennessee	16	12,196		16	8,374	.02
Alaska	17	10,300	.01	17	7,943	
Michigan	18			18		
		335,315,601	100.00		355,927,716	100.00

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Rank of petroleum-producing States in 1917 and 1918—Continued.

By value.

State.	1917			1918		
	Rank.	Value.	Per-centage.	Rank.	Value.	Per-centage.
Oklahoma	1	$181,646,981	34.26	1	$231,136,205	32.83
California	2	86,161,764	16.49	2	118,770,790	16.87
Kansas	3	67,120,573	12.84	3	100,546,202	14.28
Texas	4	42,891,555	8.21	4	74,867,537	10.64
Illinois	5	31,358,069	6.00	6	31,230,000	4.44
West Virginia	6	27,246,960	5.21	5	31,652,018	4.50
Pennsylvania	7	25,154,290	4.81	7	29,606,079	4.21
Ohio	8	21,104,483	4.04	9	23,465,197	3.33
Louisiana	9	17,224,602	3.30	8	27,535,060	3.91
Wyoming	10	11,047,876	2.11	10	18,159,778	2.58
Kentucky	11	7,033,714	1.35	11	11,287,162	1.60
New York	12	2,850,378	.54	12	3,307,814	.47
Indiana	13	1,470,548	.28	13	2,028,129	.29
Montana	14	146,272	.03	15	125,828	.02
Colorado	15	128,100	.02	14	188,472	.03
Tennessee	16	28,448	.01	16	21,704	
Alaska	17	20,600		17	15,986	
Michigan	18			18		
	.....	522,635,213	100.00	.....	703,943,961	100.00

CLASSIFICATION BY FIELDS.

GENERAL STATEMENT.

For convenience of discussion the oil pools of the United States are grouped in certain major areas or fields based originally on geographic position alone. As these fields have been extended areally, the geographic boundaries have become less distinct, and the separation has come to indicate more and more fundamental differences in the type of oil produced and its adaptability to refining needs. Thus the oils of the Appalachian field are in the main of paraffin base, free from asphalt and objectionable sulphur, and they yield by ordinary refining methods high percentages of gasoline and illuminating oils—the products in greatest demand. Contrasted with these oils is the petroleum of the Lima-Indiana field, which contains some asphalt, though consisting chiefly of paraffin hydrocarbons, and is contaminated with sulphur compounds which necessitate special treatment for their elimination.

Illinois oils contain varying proportions of both asphalt and paraffin and differ considerably as to specific gravity and products of distillation. Sulphur is generally present, but rarely in such form as to necessitate special treatment for its removal.

Mid-Continent oils vary in composition within wide limits, ranging from asphaltic oils, poor in gasoline and illuminants, to oils in which the asphalt content is negligible and the paraffin content relatively high and which yield correspondingly high percentages of the lighter products on distillation. Sulphur is present in varying quantities in the lower-grade oils, in certain of which—Healdton grade, for example—it exists in the form requiring special treatment for its elimination.

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Oils from the Gulf field are characterized by relatively high percentages of asphalt and low percentages of the lighter products of distillation. Considerable sulphur is present, much of which, however, is in the form of sulphureted hydrogen and is easily removed by steam before refining or utilizing the oil as fuel.

Oils from Wyoming and Colorado are in the main of paraffin base, suitable for refining by ordinary methods. Heavy asphaltic oils of fuel grade are also obtained in certain of the Wyoming fields. The California oils are generally characterized by much asphalt and little or no paraffin and by varying proportions of sulphur. The chief products are fuel oils, lamp oils, lubricants, and oil asphalt, though low percentages of naphthas may be derived from certain of the lighter oils, notably those of the Santa Maria, Sespe, and Santa Paula fields, in the southern part of the State.

PETROLEUM PRODUCED.

The following table shows the annual distribution, by fields, of the petroleum produced in the United States since 1859 and the total quantity contributed by each field since the beginning of the petroleum industry in this country:

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Petroleum produced in the United States, 1859–1918, by fields, in barrels of 42 gallons.

Year.	Appalachian.	California.	Lima-Indiana.	Rocky Mountain.	Illinois.	Mid-Continent.	Gulf.	Other.	United States.
	Barrels.	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*
Prior to 1908	947,150,206	201,965,825	386,969,115	8,960,070	28,866,683	94,651,699	138,023,394	[a]21,471	1,806,608,463
1908	24,945,517	44,854,737	10,032,305	397,428	33,686,238	48,823,747	15,772,137	[a]15,246	178,527,355
1909	26,535,844	55,471,601	8,211,443	330,917	30,898,339	50,833,740	10,883,240	[a]5,750	183,170,874
1910	26,892,579	73,010,560	7,253,861	355,224	33,143,362	59,217,582	9,680,465	[a]3,615	209,557,248
1911	23,749,832	81,134,391	6,231,164	413,621	31,317,038	66,595,477	10,999,873	[a]7,996	220,449,391
1912	26,338,516	87,272,593	4,925,906	1,778,358	28,601,308	65,473,323	8,545,040	.....	222,935,044
1913	25,921,785	97,788,525	4,773,138	2,595,321	23,893,899	84,920,225	8,542,494	[b]10,843	248,446,230
1914	24,101,048	99,775,327	5,062,543	3,783,148	21,919,749	97,994,900	12,118,028	[c]7,792	265,762,535
1915	22,860,048	86,591,535	4,269,591	4,454,000	19,041,695	123,294,317	20,578,663	[c]14,265	281,104,104
1916	23,009,455	90,951,936	3,905,003	6,476,289	17,714,235	136,934,489	21,768,090	[c]7,705	300,767,156
1917	24,932,205	93,877,549	3,670,293	9,199,310	15,776,860	168,506,206	24,342,879	[d]10,300	335,315,601
1918	25,401,466	97,531,997	3,220,722	12,808,896	13,365,974	179,383,098	24,207,628	[d]7,949	355,927,716
	1,221,838,501	1,110,226,576	448,525,084	51,552,582	298,225,380	1,171,628,752	306,461,919	112,925	4,608,571,719

[a] Michigan and Missouri.
[b] Alaska, Michigan, Missouri, and New Mexico.
[c] Alaska, Michigan, and Missouri.
[d] Alaska and Michigan.

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Petroleum produced in the United States in 1917 and 1918, by fields.

Field.	Quantity.				Value.		Average price per barrel.	
	1917 (barrels).	1918 (barrels).	Increase or decrease in 1918.					
			Barrels.	Per cent.	1917	1918	1917	1918
Appalachian	24,932,205	25,401,466	+ 469,261	+ 1.88	$77,786,495	$93,917,171	$3.120	$3.697
Lima-Indiana	3,670,293	3,220,722	− 449,571	− 12.25	7,102,326	7,450,932	1.935	2.313
Illinois	15,776,860	13,365,974	− 2,410,886	− 15.28	31,358,669	31,230,000	1.988	2.337
Mid-Continent	163,506,205	179,383,098	+15,876,893	+ 9.71	282,796,124	393,031,158	1.730	2.191
Gulf	24,342,879	24,207,620	− 135,259	− .56	26,087,587	41,063,846	1.071	1.696
California	93,877,549	97,531,997	+ 3,654,448	+ 3.89	86,161,764	118,770,790	.918	1.218
Rocky Mountain	9,199,310	12,808,896	+ 3,609,586	+ 39.24	11,322,248	18,474,078	1.231	1.442
Other fields	a10,300	a 7,943	− 2,357	− 22.88	a 20,600	a 15,986	2.000	2.013
	335,315,601	355,927,716	+20,612,115	+ 6.15	522,635,213	703,943,961	1.559	1.978

a Alaska and Michigan.

Percentages of petroleum produced in the several fields, 1914–1918.

Field.	1914	1915	1916	1917	1918
Appalachian	9.07	8.13	7.650	7.44	7.14
Lima-Indiana	1.90	1.52	1.298	1.09	.90
Illinois	8.25	6.77	5.890	4.70	3.76
Mid-Continent	36.87	43.96	45.528	48.76	50.40
Gulf	4.94	7.32	7.238	7.26	6.80
California	37.54	30.81	30.240	28.00	27.40
Rocky Mountain	1.43	1.585	2.153	2.75	3.60
Other fields		.005	.003		
	100.00	100.000	100.000	100.00	100.00

DELIVERIES.

Petroleum delivered to trade in 1917 and 1918, in barrels.

Field.	1917			1918		
	Refining.	Fuel.	Total.	Refining.	Fuel.	Total.
Appalachian	a 24,956,413	3,920	24,960,333	b 25,573,607	32,912	25,606,519
Lima-Indiana	3,843,401	9,016	3,852,417	4,086,326	c 11,829	4,098,155
Illinois	18,808,647	6,963	18,815,610	14,499,661	d 59,783	14,559,444
Mid-Continent	161,350,934	3,129,824	164,480,748	196,474,640	3,241,238	199,715,878
Gulf	19,209,191	6,063,275	25,272,466	19,425,685	4,998,347	24,424,032
California	67,966,889	36,781,719	104,748,608	64,610,469	34,810,210	99,420,679
Rocky Mountain	8,752,737	686,713	9,429,150	12,330,449	86,997	12,409,503
Other			10,300			7,943
	304,888,202	46,681,430	351,569,632	337,000,837	43,241,316	380,242,153

a Includes 40,180 barrels of lubricating oil.
b Includes 27,823 barrels of lubricating oil.
c Includes small quantity used for hog dip.
d Includes 366 barrels used for hog dip and street sprinkling.

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STOCKS AND STORAGE.

By far the larger quantity of unused crude petroleum above ground in the United States is held in large storage farms by the pipe-line and marketing companies. Oil thus held is described as "pipe-line stocks" or "stocks." A smaller quantity of crude oil is also held in storage at refineries, in most places only a quantity necessary for immediate use. Such oil is described as "refinery stocks." In general the producing companies do not hold oil in storage except as they are forced to do so by lack of marketing facilities. In newly developed territory, however, the quantity of crude oil held in storage by the producers themselves sometimes reaches considerable magnitude. Oil run into such temporary storage is included in field stocks. Another type of stored oil which has hitherto been included in field stocks is oil held in storage by certain marketing companies which are not, however, pipe-line companies. Such stocks are in this report included in pipe-line stocks, although in previous years they have been included in field stocks.

PIPE-LINE STOCKS.

The statistics tabulated below show the quantities of crude oil of various grades in the custody of the pipe-line companies of the United States at the close of business on December 31, and include also the stocks held at storage centers by important purchasing and marketing agencies other than pipe-line companies.

Stocks of all grades of petroleum at the end of 1917 and 1918, in barrels.

Grade of oil.	Held by eastern pipe lines and refineries.[a]		In pipe-line storage outside of eastern field.		Total.		Increase or decrease.
	1917	1918	1917	1918	1917	1918	
Pennsylvania [b]	3,821,416	3,616,363	.....	.....	3,821,416	3,616,363	− 205,053
Lima	1,906,241	1,028,808	.....	.....	1,906,241	1,028,808	− 877,433
Illinois [c]	502,312	424,604	3,057,910	1,942,148	3,560,222	2,366,752	− 1,193,470
Mid-Continent	4,356,420	4,176,355	95,070,003	74,917,288	99,426,423	79,093,643	−20,332,780
Gulf	.....	.....	8,384,814	8,168,402	8,384,814	8,168,402	− 216,412
California	.....	.....	28,427,292	26,538,610	28,427,292	26,538,610	− 1,888,682
Rocky Mountain	.....	.....	515,341	914,734	515,341	914,734	+ 399,393
	10,586,389	9,246,130	135,455,360	112,481,182	146,041,749	121,727,312	−24,314,437

[a] These pipe lines connect with the delivering lines of the Illinois, Kansas, and Oklahoma fields and receive and transfer large quantities of these western oils to the Atlantic seaboard in addition to the oil from wells directly tributary to their own systems.
[b] Includes natural lubricating oil from Pennsylvania and West Virginia.
[c] Includes some Indiana oil of Illinois grade.

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REFINERY STOCKS.

Statistics compiled and published by the Bureau of Mines show that the quantity of crude oil on hand at the petroleum refineries of the United States at the close of business on December 31, 1918, was not less than 15,700,000 barrels. A small part of this working stock is certainly duplicated in the foregoing tabulation of pipe-line stocks, owing to the fact that many refining companies which receive all or a part of their supply of crude oil through private pipe lines make no distinction in their records between pipe-line and refinery stocks of crude oil.

FIELD STORAGE.

The following table shows the quantity of unmarketed petroleum reported by the producers as held in field tanks and reservoirs at the close of business on December 31, 1917 and 1918:

Petroleum in field storage at end of 1917 and 1918.

	1917	1918
	Barrels.	*Barrels.*
Appalachian field	310,966	242,291
Lima-Indiana field	71,018	26,032
Illinois field	213,349	298,225
Mid-Continent field	8,378,031	2,183,106
Gulf field	121,001	413,582
Rocky Mountain field	294,524	260,040
California field	4,316,922	4,123,821
	13,705,811	7,547,097

SUMMARY OF WELLS DRILLED.

The following tables compiled from trade journals with the exception of the statistics for Alaska, California, Colorado, Michigan, Missouri, Montana, Utah, Wyoming, and miscellaneous, which are taken from reports furnished by the oil producers themselves, show in condensed form the results of activity in drilling for oil in the United States in the last two years.

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Wells drilled in the United States in 1917 and 1918.

Field.*	Wells completed.				Initial daily production (barrels).	
	Oil.	Gas.	Dry.	Total.	Total.	Average per well.
1917.						
Appalachian:						
Pennsylvania and New York	1,936	266	356	2,558	9,760	5.0
Southeastern and central Ohio	868	456	504	1,828	11,976	13.8
West Virginia	933	435	267	1,635	14,867	15.9
Kentucky	1,162	59	417	1,638	35,293	30.4
Tennessee	8	3	.....	11	615	76.9
	4,907	1,219	1,544	7,670	72,511	14.8
Lima, Ohio	473	9	52	534	7,364	15.6
Indiana	174	9	83	266	4,914	28.2
	647	18	135	800	12,278	19.0
Illinois	488	9	149	646	10,128	20.8
Mid-Continent:						
Kansas	2,712	177	538	3,427	319,093	117.7
Oklahoma	5,027	410	1,360	6,797	365,314	72.7
Central and northern Texas	729	24	292	1,045	51,153	70.2
Northern Louisiana	302	56	98	456	59,272	196.3
	8,770	667	2,288	11,725	794,832	90.6
Gulf:						
Coastal and southern Texas	770	49	517	1,336	445,263	578.3
Coastal Louisiana	93	4	81	178	46,210	496.9
	863	53	598	1,514	491,473	569.5
Alaska	.....	.....	2	2	.....	.....
California	686	.....	48	734	.....	.....
Colorado	3	.....	17	20	.....	.....
Missouri	.....	.....	2	2	.....	.....
Montana	1	.....	1	2	.....	.....
Wyoming	225	.....	50	275	.....	.....
Miscellaneous	.....	.....	17	17	.....	.....
	16,690	1,966	4,851	23,407	.....	.....
1918.						
Appalachian:						
Pennsylvania and New York	1,477	212	219	2,008	4,621	2.9
Southeastern and central Ohio	803	446	446	1,695	12,019	15.0
West Virginia	741	329	240	1,310	14,762	19.9
Kentucky	1,737	78	352	2,167	48,621	28.0
Tennessee	14	3	6	23	258	18.4
	4,872	1,068	1,263	7,203	80,281	16.4
Lima, Ohio	369	9	38	416	5,500	14.9
Indiana	169	8	100	277	4,568	27.0
	538	17	138	693	10,068	18.7
Illinois	279	9	108	396	5,877	21.1
Mid-Continent:						
Kansas	3,458	269	939	4,666	334,933	96.9
Oklahoma	5,495	762	2,119	8,376	375,647	68.4
Central and northern Texas	891	24	304	1,219	147,401	165.4
Northern Louisiana	389	56	73	518	171,105	439.9
	10,233	1,111	3,435	14,779	1,029,086	100.6
Gulf:						
Coastal and southern Texas	838	22	389	1,249	280,247	334.4
Coastal Louisiana	117	2	75	194	36,690	313.6
	955	24	464	1,443	316,937	331.9
Alaska	1	.....	.....	1	.....	.....
California	676	.....	63	736	.....	.....
Colorado	12	.....	11	23	.....	.....
Montana	2	.....	6	8	.....	.....
Wyoming	277	.....	115	392	.....	.....
Miscellaneous	.....	.....	10	10	.....	.....
	17,845	2,229	5,613	25,684	.....	.....

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Percentage of dry holes, 1909–1918.

Division.	1909	1910	1911	1912	1913	1914	1915	1916	1917	1918
Pennsylvania and New York	a 15.7	a 23.9	14.8	18.0	12.3	11.8	14.9	9.7	13.9	10.9
Southeastern Ohio	a 36.0	a 41.9	30.5	26.8	27.5	25.3	24.7	28.3	27.5	26.3
West Virginia	a 38.9	a 44.5	18.3	14.1	16.4	19.7	19.1	16.5	16.3	18.2
Kentucky	a 46.2	a 42.1	24.3	34.3	32.9	30.9	39.1	16.7	25.5	16.2
Tennessee	.....	.....	.....	.....	.....	.....	53.8	77.8	.....	26.1
Appalachian	a 26.8	a 35.6	21.1	17.9	17.6	18.4	20.0	16.8	20.1	17.5
Lima, Ohio	a 9.7	10.0	6.1	10.0	9.3	8.1	10.3	10.3	9.7	9.1
Indiana	a 28.2	18.0	29.9	22.5	27.7	34.9	44.8	36.8	31.2	36.1
Lima-Indiana	a 14.5	13.1	10.4	11.7	13.7	20.6	25.0	17.6	16.9	19.9
Illinois	a 17.7	18.3	19.3	20.4	16.2	22.5	26.3	21.7	23.0	27.3
Kansas	19.0	19.2	23.0	16.9	12.9	11.5	13.5	10.2	15.7	20.1
Oklahoma	11.6	10.8	12.0	14.1	14.8	16.2	19.1	14.8	20.0	25.3
Northern Texas	25.7	a 43.2	30.2	28.6	26.0	29.7	37.5	21.2	27.9	24.9
Northern Louisiana	27.3	23.9	18.5	17.6	17.9	21.0	19.2	27.1	21.7	14.1
Mid-Continent	13.6	13.5	13.8	15.4	15.3	16.3	19.7	14.3	19.5	23.2
Coastal Texas	29.9	24.1	23.3	23.5	43.1	26.0	42.5	34.5	38.7	31.1
Coastal Louisiana	45.1	23.8	26.6	29.8	40.6	38.1	25.7	28.1	45.5	38.7
Gulf	31.5	a 24.0	24.4	24.5	42.6	30.1	39.9	33.7	39.5	32.2

Average initial daily production, 1909–1918.

Division.	1909	1910	1911	1912	1913	1914	1915	1916	1917	1918
Pennsylvania and New York	3.2	4.0	3.3	3.5	2.6	2.9	6.6	4.3	5.0	2.9
Southeastern Ohio	17.9	19.0	14.3	28.6	13.1	14.0	12.4	11.7	13.8	15.0
West Virginia	38.3	29.2	16.8	103.4	27.1	28.5	17.7	23.0	15.9	19.9
Kentucky	23.8	11.8	18.2	17.4	16.7	13.2	13.0	31.1	30.4	28.0
Tennessee	.....	.....	.....	.....	.....	.....	62.5	22.5	76.9	18.4
Appalachian	13.3	14.4	9.4	36.3	10.2	10.5	11.1	13.7	14.7	16.2
Lima, Ohio	10.3	13.5	13.3	15.0	12.8	12.2	20.1	15.1	15.6	14.9
Indiana	17.6	30.5	14.8	16.7	34.7	18.0	26.2	22.2	28.2	27.0
Lima-Indiana	11.9	19.6	13.5	15.2	17.1	14.4	21.9	16.6	19.0	13.7
Illinois	34.6	55.6	63.0	67.0	34.8	33.0	26.3	22.4	20.8	21.1
Kansas	19.0	22.3	19.0	13.5	15.8	10.8	18.6	79.2	117.7	96.9
Oklahoma	75.3	71.1	79.6	48.6	48.0	152.3	305.0	85.8	72.7	68.4
Northern Texas	10.8	15.6	228.3	94.3	98.9	50.3	171.5	99.5	70.2	165.3
Northern Louisiana	127.0	1,128.6	687.5	351.9	426.8	338.4	567.7	109.4	196.3	439.9
Mid-Continent	72.7	105.6	119.6	60.2	60.7	125.2	278.4	87.1	90.6	100.6
Coastal Texas	89.7	173.5	93.0	93.7	119.9	497.5	956.0	600.3	577.5	334.4
Coastal Louisiana	373.5	475.9	1,176.9	432.5	688.1	1,151.6	619.0	1,070.3	496.9	313.6
Gulf	114.4	197.8	257.6	142.2	233.3	616.7	891.1	665.4	568.9	331.9

a Including gas wells.

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PETROLEUM OPERATORS' STATISTICS.

The statistics presented in this section are those obtained directly from the oil producers The object of this investigation, in addition to providing a check on the determination of petroleum produced, as reported by the pipe-line and other oil-transporting companies, is to procure a record of petroleum utilized in field operations and to obtain details available in no other way concerning field storage, drilling activity, and acreage held for development.

It will be noted that the statistics of wells completed as given in this section differ with respect to many States and districts from those given elsewhere in this chapter. The statistics presented here are those obtained from voluntary reports by the petroleum operators themselves and relate merely to the number of wells owned or operated by the particular companies reporting. Those published elsewhere, with the exception of the field reports for Colorado, Wyoming, Montana, California, Missouri, Alaska, and miscellaneous, which are obtained from the statements of the operators, are compiled from trade journals, principally the Oil City Derrick and the Oil and Gas Journal, and are published because they are consistent since the beginning of the oil industry in the United States and because they furnish, in addition to the number of wells completed, an approximation of the output of each well the first day of its productive life.

Well record and acreage held by operators in the United States in 1918.

[From statistics furnished by producers.]

State.	Wells.					Acreage.		
	Productive Jan. 1.	Completed.		Abandoned.	Productive Dec. 31.	Fee.	Lease.	Total.
		Oil.	Dry.					
Alaska	7	1	.....	.....	8	151	3,000	3,151
Arkansas	.....	.....	4	.....	.....	.....	20,000	20,000
California	8,364	676	63	72	8,968	325,174	119,222	444,396
Colorado	91	12	11	3	100	11,419	64,816	76,235
Illinois	16,124	245	58	365	16,004	3,459	156,357	159,816
Indiana	1,940	126	51	263	1,803	2,686	36,791	39,477
Kansas	7,509	1,731	444	558	8,682	44,744	2,065,087	2,109,831
Kentucky	2,893	1,011	312	280	3,624	47,888	914,512	962,400
Louisiana	1,885	446	72	138	2,193	20,054	396,607	416,661
Michigan	28	.....	.....	6	22	15	45	60
Missouri	14	.....	1	2	12	.....	20,000	20,000
Montana	7	2	6	1	8	4,160	39,440	43,600
New Mexico	1	.....	3	1	.....	.....	300	300
New York	11,411	166	9	183	11,394	32,908	69,044	101,952
Ohio	29,978	918	226	1,396	29,500	51,447	1,407,930	1,459,377
Oklahoma	35,137	3,269	810	686	37,720	66,751	2,480,762	2,547,513
Oregon	.....	.....	1	.....	.....	.....	4,480	4,480
Pennsylvania	58,852	941	176	900	58,893	308,610	909,990	1,218,600
Tennessee	4	7	8	5	6	1,555	55,800	57,355
Texas	6,015	1,598	330	479	7,134	112,735	2,414,022	2,526,757
Utah	4	.....	.....	.....	4	.....	10,000	10,000
Washington	.....	.....	1	.....	.....	.....	3,000	3,000
West Virginia	16,169	685	134	485	16,369	339,944	1,683,771	2,023,715
Wyoming	716	277	115	62	931	20,710	160,805	181,515
	197,149	12,111	3,135	5,885	203,375	1,394,410	3,035,781	14,430,191
Total, 1917	190,086	13,860	2,988	6,797	197,149	1,019,233	11,435,678	12,454,911

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Well record and acreage held by operators in the United States in 1918—Continued.

New York.

County.	Wells.					Acreage.		
	Productive Jan. 1.	Completed.		Abandoned.	Productive Dec. 31.	Fee.	Lease.	Total.
		Oil.	Dry.					
Allegany	7,924	124	5	103	7,945	16,764	36,766	53,530
Cattaraugus	3,267	42	4	80	3,229	14,644	31,243	45,887
Steuben	220	.....	.....	.....	220	1,500	1,035	2,535
	11,411	166	9	183	11,394	32,908	69,044	101,952
Total, 1917	11,200	251	4	40	11,411	34,207	65,992	100,199

Pennsylvania.

Allegheny	1,741	58	25	86	1,713	3,771	77,277	81,048
Armstrong	205	.....	2	9	196	1,228	6,556	7,784
Beaver	648	31	7	27	652	1,141	16,259	17,400
Butler	5,432	40	30	177	5,295	23,512	67,236	90,748
Clarion	2,008	57	11	24	2,041	10,039	70,507	80,546
Crawford	734	.....	.....	22	712	849	3,592	4,441
Elk	1,155	8	3	4	1,159	30,894	69,594	100,488
Forest	1,669	47	14	18	1,698	43,111	33,971	77,082
Greene	552	7	13	15	544	590	147,831	148,421
Jefferson	155	12	2	3	164	955	38,428	39,383
Lawrence	944	9	1	68	885	2,075	10,496	12,571
McKean	16,034	296	13	114	16,216	70,294	130,090	200,384
Mercer	260	3	0	34	229	3,758	6,771	10,529
Potter	73	.....	.....	.....	73	1,286	622	1,908
Tioga	24	5	.....	.....	29	80	120	200
Venango	17,918	302	33	103	18,117	71,310	73,322	144,632
Warren	7,470	33	9	158	7,345	41,011	46,556	87,567
Washington	1,830	33	13	38	1,825	2,706	110,762	113,468
	58,852	941	176	900	58,893	308,610	909,990	1,218,600
Total, 1917	58,417	1,379	182	944	58,852	310,850	857,309	1,168,159

West Virginia.

Braxton	11	.....	.....	3	8	.....	1,504	1,504
Boone	.....	1	.....	1	.....	.....	.....	.....
Brooke	276	3	5	23	256	592	6,534	7,126
Cabell	15	1	.....	.....	16	198	1,582	1,780
Calhoun	298	10	.....	7	301	4,248	5,696	9,944
Clay	101	5	1	1	105	7,843	42,107	49,950
Doddridge	638	42	13	20	660	1,232	84,287	85,519
Gilmer	104	7	3	9	102	.....	69,283	69,283
Hancock	314	16	2	33	297	1,052	4,116	5,168
Harrison	1,327	11	.....	62	1,276	2,352	82,498	84,850
Jackson	2	2	1	.....	4	.....	21,393	21,393
Kanawha	994	91	3	27	1,058	6,129	319,185	325,314
Lewis	266	9	.....	5	270	80	68,763	68,843
Lincoln	932	22	1	5	949	280,421	332,084	612,505
Marion	785	70	15	28	827	240	62,136	62,376
Marshall	131	8	4	6	133	8,090	16,515	24,605
Mercer	.....	.....	8	.....	.....	.....	.....	.....
Monongalia	714	17	.....	8	723	1,068	39,315	40,383
Ohio	4	.....	.....	.....	4	.....	5	5
Pleasants	1,766	43	20	61	1,748	496	30,008	30,504
Putnam	1	2	1	.....	3	.....	517	517
Ritchie	1,963	82	19	32	2,013	4,188	88,144	92,332
Roane	1,296	88	5	8	1,376	11,894	201,571	213,465
Taylor	1	.....	.....	.....	1	.....	9,646	9,646
Tyler	1,551	16	5	68	1,499	80	65,973	66,053
Wayne	6	1	.....	2	5	.....	1,096	1,096
Wetzel	1,115	62	5	24	1,153	1,575	100,004	101,579
Wirt	507	36	12	38	505	2,913	13,571	16,484
Wood	1,061	40	11	14	1,077	5,253	16,238	21,491
	16,169	685	134	485	16,369	339,944	1,683,771	2,023,715
Total, 1917	15,918	803	103	552	16,169	176,862	1,708,093	1,884,955

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Well record and acreage held by operators in the United States in 1918—Continued.

Kentucky.

County.	Wells.					Acreage.		
	Productive Jan. 1.	Completed.		Abandoned.	Productive Dec. 31.	Fee.	Lease.	Total.
		Oil.	Dry.					
Adair	2			2				
Allen	144	82	22	6	220	1,233	79,033	80,266
Barren	18	30	6		48	432	11,604	12,036
Bath	90	2	15	1	91	594	3,885	4,479
Boyle	1			1				
Breathitt		2	5		2		44,900	44,900
Bullitt			2				3,300	3,300
Clark		8			8	15	29	44
Daviess			1				11,000	11,000
Estill	1,247	221	82	171	1,297	11,914	344,225	356,139
Floyd	22	4	1	2	24		8,325	8,325
Grant			2				14,000	14,000
Grayson	1	4	1		5		29,000	29,000
Hart			1				9,339	9,339
Hopkins		1			1		6,000	6,000
Jackson	4		1		4		10,113	10,113
Jessamine			1					
Knott	2				2		530	530
Knox	10		4		10	640	6,274	6,914
Laurel			1					
Lawrence	88	25	3	6	107	919	17,297	18,216
Lee	52	365	40	3	414	23,014	112,216	135,230
Lewis			1					
Lincoln	7	11	6		18		25,551	25,551
McCreary	30	2	1	7	25	6,000	5,036	11,036
Magoffin			4				13,500	13,500
Mason		4			4		131	131
Menifee		3			3	7	1,600	1,607
Metcalfe	3	3			6		6,150	6,150
Montgomery			8				1,000	1,000
Morgan	31	5	3	9	27	360	2,117	2,477
Ohio	4				4		1,200	1,200
Owsley			5				2,441	2,441
Powell	283	193	60	5	471	265	9,634	9,899
Pulaski		5	4		5		2,500	2,500
Rockcastle	4			4				
Rowan	35				35		2,500	2,500
Simpson	1	1	1	1	1		5,000	5,000
Warren	4	1	2	5			56,100	56,100
Wayne	647	18	21	37	628	2,495	49,903	52,398
Whitley	5		1		5		3,000	3,000
Wolfe	158	21	7	20	159		16,079	16,079
Total, 1918	2,893	1,011	312	280	3,624	47,888	914,512	962,400
Total, 1917	1,879	1,101	344	87	2,893	45,454	1,410,250	1,455,704

Ohio.

Allen	857	24		107	774	872	12,750	13,622
Ashland	4	1	6		5		253,527	253,527
Athens	161	35	9	7	189	185	4,937	5,122
Auglaize	324	53		45	332	238	10,598	10,836
Belmont	183	2	5	7	178		42,753	42,753
Carroll	123	23	39	9	137	160	86,464	86,624
Columbiana	385	4	7		389	1,183	7,203	8,386
Coshocton	86	15	4	2	99	6	39,258	39,264
Cuyahoga	5	2			7		150	150
Erie	2				2		500	500
Fairfield	276	3	1	10	269	737	16,018	16,755
Guernsey	9	2	1		11		760	760
Hancock	3,008	35	4	69	2,974	929	32,414	33,343
Hardin	7				7	40	760	800
Harrison	645	22	1	14	653	2,141	8,262	10,403
Hocking	404	68	8		472	1,517	55,630	57,147
Holmes	47	24	4	1	70		26,735	26,735
Jefferson	537	25	15	6	556	863	16,502	17,365
Knox	21		1	3	18		14,777	14,777
Lawrence	16				16		313	313
Licking	105	14	2		119	246	48,315	48,561
Logan	2				2		230	230
Lorain	9				9		1,000	1,000

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Well record and acreage held by operators in the United States in 1918—Continued.

Ohio—Continued.

County.	Wells.					Acreage.		
	Productive Jan. 1.	Completed.		Abandoned.	Productive Dec. 31.	Fee.	Lease.	Total.
		Oil.	Dry.					
Lucas	414	1	2	83	332	954	5,929	6,883
Mahoning	148	16	.....	.....	164	456	1,329	1,785
Medina	4	20	1	.....	24	.....	1,780	1,780
Meigs	8	18	4	2	24	.....	2,260	2,260
Mercer	622	24	.....	31	615	676	9,001	9,677
Monroe	2,511	21	20	71	2,461	4,737	36,994	41,731
Morgan	1,338	43	4	58	1,323	1,532	10,591	12,123
Muskingum	279	51	.....	6	324	1,752	27,095	28,847
Noble	570	22	7	6	586	1,450	8,056	9,506
Ottawa	293	24	1	108	209	790	5,176	5,966
Paulding	1	.....	.....	1	.....	.....	1,800	1,800
Perry	692	63	9	43	712	1,771	51,156	52,927
Sandusky	3,703	30	1	226	3,507	4,964	36,639	41,603
Seneca	678	33	13	184	577	1,040	8,720	9,760
Shelby	17	.....	.....	3	14	.....	320	320
Trumbull	22	.....	.....	3	19	500	813	1,313
Van Wert	308	10	1	65	263	84	405,479	405,563
Vinton	50	5	1	1	54	60	5,574	5,634
Washington	4,063	93	51	69	4,087	8,400	51,480	59,880
Wayne	87	29	4	1	115	3,000	3,510	6,510
Wood	6,954	63	.....	215	6,802	10,164	54,372	64,536
Total, 1917	29,978 31,144	918 890	226 184	1,396 2,056	29,560 29,978	51,447 48,054	1,407,930 723,226	1,459,377 771,280
Indiana.								
Adams	172	4	.....	25	151	90	2,248	2,338
Allen	7	9	1	.....	16	.....	1,132	1,132
Blackford	39	.....	.....	7	32	.....	766	766
Daviess	.....	3	.....	.....	3	.....	40	40
Delaware	25	5	1	14	26	155	1,350	1,505
Gibson	101	22	7	7	116	.....	2,043	2,043
Grant	12	.....	.....	1	11	.....	100	100
Greene	5	.....	.....	3	2	.....	275	275
Huntington	43	3	1	25	21	.....	320	320
Jay	496	.....	1	55	441	1,905	7,342	9,247
Knox	2	.....	.....	.....	2	.....	1,000	1,000
Madison	.....	.....	1	.....	.....	.....	400	400
Miami	17	.....	.....	.....	17	.....	1,300	1,300
Pike	219	57	29	22	254	96	4,012	4,108
Randolph	43	9	.....	18	34	200	3,610	3,810
Sullivan	524	9	10	58	480	160	5,427	5,587
Vigo	18	.....	.....	2	16	.....	356	356
Wabash	10	.....	.....	.....	10	.....	256	256
Wells	197	5	.....	31	171	80	4,814	4,895
Total, 1917	1,940 2,545	126 121	51 34	263 726	1,803 1,940	2,686 2,522	36,791 64,625	39,477 67,147
Illinois.								
Clark	2,487	57	7	38	2,506	314	18,664	18,978
Clinton	159	4	2	10	153	.....	3,663	3,663
Coles	60	2	.....	.....	62	160	245	405
Crawford	7,856	111	27	208	7,759	397	76,505	76,902
Cumberland	779	1	.....	.....	780	43	4,623	4,666
Edgar	15	5	.....	6	15	504	470	974
Hancock	11	.....	.....	.....	11	.....	155	155
Jasper	9	.....	.....	.....	9	.....	160	160
Lawrence	4,196	47	11	91	4,152	1,761	40,845	42,606
McDonough	407	10	1	11	406	.....	7,663	7,663
Macoupin	6	.....	.....	.....	6	.....	600	600
Madison	3	.....	.....	.....	3	.....	350	350
Marion	105	.....	2	.....	105	.....	1,428	1,428
Morgan	3	.....	.....	.....	3	160	396	556
Wabash	28	8	8	2	34	120	590	710
Total, 1917	16,124 15,839	245 665	58 120	365 380	16,004 16,124	3,459 5,367	156,357 165,619	159,816 170,986

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Well record and acreage held by operators in the United States in 1918—Continued.

Kansas.

County.	Wells.					Acreage.		
	Productive Jan. 1.	Completed.		Abandoned.	Productive Dec. 31.	Fee.	Lease.	Total.
		Oil.	Dry.					
Allen	450	104	23	60	494	960	32,332	33,292
Anderson	8	14	12	3	19		6,425	6,425
Atchison			2			2,812		2,812
Barber			2				2,000	2,000
Bourbon	1		3		1		1,000	1,000
Butler	1,870	802	136	43	2,629	27,544	1,027,854	1,055,398
Chase			1				6,400	6,400
Chautauqua	1,785	133	46	18	1,900	7,677	73,314	80,991
Cloud			2					
Coffey	31	9	4	2	38		2,832	2,832
Cowley	10	1	4		11	150	82,990	83,140
Crawford			1				80	80
Dickinson			1				20,000	20,000
Douglas			1				4,000	4,000
Elk	73	10	6	5	78	19	4,269	4,288
Franklin	381	53	18	55	379	160	43,357	43,517
Greenwood	9	37	17	4	42	120	36,613	36,733
Hodgeman			1				700	700
Johnson	3	1			4		4,000	4,000
Labette	51	40	4		91		3,220	3,220
Linn	2	21	7		23	200	7,700	7,900
McPherson			1				3,000	3,000
Miami	247	66	23	65	248	202	13,107	13,309
Montgomery	1,706	133	51	164	1,675	2,093	462,090	464,183
Neosho	604	149	18	107	646	1,940	104,859	106,799
Pawnee			1					
Reno			1					
Sedgwick			1					
Smith			1					
Sumner			1					
Wabaunsee			1				8,000	8,000
Wilson	254	135	54	22	367	867	102,433	103,300
Woodson	24	23		10	37		12,512	12,512
Total, 1917	7,509	1,731	444	558	8,682	44,744	2,065,087	2,109,831
	5,843	2,167	422	501	7,509	26,065	2,128,119	2,154,184

Oklahoma.

Adair			1				1,000	1,000
Alfalfa			4				9,500	9,500
Atoka			2					
Blaine			2				5,050	5,050
Caddo			2				13,000	13,000
Canadian			3			80	2,000	2,080
Carter	1,811	277	33	18	2,070	10,007	116,804	126,811
Cleveland			1					
Comanche	13	1	1	2	12	20	5,120	5,140
Cotton		10	3		10		12,555	12,555
Craig	16	2	4		18		1,207	1,207
Creek	5,533	329	78	46	5,816	7,313	304,594	311,907
Dewey			1					
Garfield	62	127	13		189		115,949	115,949
Garvin	13		2		13		1,060	1,060
Grady			3				240	240
Harmon			1					
Jefferson	17	2	2		19		20,112	20,112
Kay	207	131	50	43	295	910	217,291	218,201
Kiowa	5	1	1		6		1,320	1,320
Le Flore			1					
Lincoln			2					
McClain		1	2		1		1,240	1,240
McIntosh	8				8		160	160
Marshall	3			3				
Murray			1				1,500	1,500
Muskogee	709	88	44	28	769	1,423	52,572	53,995
Noble	1	14	9	1	14	80	73,273	73,353
Nowata	7,186	285	46	66	7,405	7,446	150,315	157,761
Okfuskee	27		6		27		52,175	52,175
Okmulgee	2,023	329	123	67	2,285	10,418	231,427	241,845
Osage	3,163	583	122	42	3,704	3,269	336,710	339,979
Pawnee	801	87	14	35	853	561	78,994	79,555

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Well record and acreage held by operators in the United States in 1918—Continued.

Oklahoma—Continued.

County.	Wells.					Acreage.		
	Productive Jan. 1.	Completed.		Abandoned.	Productive Dec. 31.	Fee.	Lease.	Total.
		Oil.	Dry.					
Payne	104	101	11	.....	205	279	141,664	141,943
Pontotoc	38	51	14	2	87	.....	13,296	13,296
Pottawatomie	.....	1	3	.....	1	.....	4,740	4,740
Rogers	2,324	119	29	85	2,358	6,367	35,356	41,723
Stephens	7	45	12	1	51	25	46,929	46,954
Tulsa	4,167	260	92	54	4,373	7,547	191,727	199,274
Wagoner	185	108	21	7	286	292	56,211	56,503
Washington	6,714	317	52	186	6,845	10,714	185,671	196,385
Total, 1917	35,137	3,269	810	686	37,720	66,751	2,480,762	2,547,513
	31,930	3,825	775	618	35,137	49,195	1,752,441	1,801,636

Texas.

Archer	26	3	5	6	23	300	3,910	4,210
Austin	.....	.....	2	.....	.....	.....	.....	.....
Bastrop	.....	5	2	.....	5	.....	160	160
Bexar	75	19	2	.....	94	4,970	19,916	24,886
Brazoria	9	27	34	5	31	6,187	43,507	49,694
Brown	20	259	105	25	254	246	63,296	63,542
Callahan	.....	.....	2	.....	.....	.....	.....	.....
Chambers	.....	2	.....	.....	2	16	15,475	15,491
Clay	379	23	10	41	361	1,828	881,078	882,906
Coleman	3	9	5	.....	12	2,500	46,062	48,562
Colorado	.....	.....	1	.....	.....	.....	2,500	2,500
Cooke	.....	.....	1	.....	.....	.....	4,700	4,700
Delta	.....	.....	3	.....	.....	.....	7,000	7,000
Duval	11	7	5	5	13	840	31,322	32,162
Eastland	1	59	11	.....	60	286	110,528	110,814
Fort Bend	.....	1	1	1	.....	13	1,054	1,067
Garza	.....	.....	1	.....	.....	.....	84,000	84,000
Gonzales	.....	.....	2	.....	.....	.....	2,500	2,500
Hardin	1,182	139	60	91	1,230	6,841	12,304	19,145
Harris	807	300	127	107	1,000	7,778	41,589	49,367
Houston	.....	.....	1	.....	.....	.....	.....	.....
Hunt	.....	.....	1	.....	.....	.....	.....	.....
Jack	59	.....	.....	59	.....	.....	.....	.....
Jefferson	90	37	10	25	102	39	2,130	2,169
Johnson	.....	.....	1	.....	.....	.....	.....	.....
Liberty	4	2	2	5	1	620	2,135	2,755
Limestone	.....	.....	1	.....	.....	.....	1,000	1,000
McCullough	.....	.....	1	.....	.....	1,500	18,208	19,708
McLennan	12	.....	1	3	9	.....	2,383	2,383
McMullen	23	.....	1	.....	23	8,200	.....	8,200
Madison	.....	.....	3	.....	.....	.....	6,400	6,400
Marion	25	5	1	.....	30	3,488	2,270	5,758
Matagorda	38	.....	3	13	25	451	3,955	4,406
Montague	.....	.....	3	.....	.....	.....	12,100	12,100
Montgomery	.....	.....	1	.....	.....	.....	3,600	3,600
Nacogdoches	1	.....	2	1	.....	42	3,000	3,042
Navarro	807	38	4	14	921	1,108	12,986	14,094
Orange	1	.....	.....	1	.....	.....	.....	.....
Palo Pinto	153	5	3	.....	158	.....	227,840	227,840
Panola	.....	4	.....	.....	4	.....	11,581	11,581
Parker	1	.....	4	1	.....	.....	100	100
San Augustine	.....	.....	1	.....	.....	.....	8,500	8,500
Shackelford	19	21	5	.....	40	62	30,454	30,516
Shelby	.....	4	3	.....	4	.....	39,734	39,734
Stephens	4	15	14	.....	19	60,000	264,351	324,351
Tarrant	.....	.....	1	.....	.....	.....	1,800	1,800
Tom Green	.....	.....	2	.....	.....	.....	2,300	2,300
Washington	1	.....	.....	.....	1	1	1,000	1,001
Wichita	1,972	570	166	64	2,478	3,777	366,352	370,129
Wilbarger	65	37	12	4	98	1,632	4,012	5,644
Williamson	136	7	2	7	136	10	7,930	7,940
Wilson	1	.....	.....	1	.....	.....	.....	.....
Young	.....	.....	2	.....	.....	.....	7,000	7,000
Total, 1917	6,015	1,598	630	479	7,134	112,735	2,414,022	2,526,757
	5,253	1,264	563	502	6,015	47,535	1,023,474	1,071,009

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Well record and acreage held by operators in the United States in 1918—Continued.

Louisiana.

County.	Wells.					Acreage.		
	Productive Jan. 1.	Completed.		Abandoned.	Productive Dec. 31.	Fee.	Lease.	Total.
		Oil.	Dry.					
Acadia	104	6	4	7	103	295	12,182	12,477
Bossier	1	5	3	.....	6	190	77,505	77,695
Caddo	1,141	364	35	55	1,450	16,916	139,636	156,552
Calcasieu	120	37	7	37	120	916	1,842	2,758
Claiborne	.....	.....	1	.....	.....	.....	160	160
De Soto	146	16	7	11	151	262	85,759	88,021
Evangeline	.....	.....	1	.....	.....	.....	.....	.....
Iberia	2	2	3	3	1	867	2,221	3,088
Jefferson Davis	.....	1	.....	.....	1	.....	17	17
Rapides	.....	.....	1	.....	.....	.....	10,000	10,000
Red River	359	14	8	23	350	.....	34,869	34,869
Sabine	4	1	.....	.....	5	356	21,019	21,375
St. Martin	8	.....	1	2	6	.....	5,000	5,000
Terrebonne	.....	.....	1	.....	.....	252	6,397	6,649
Total, 1917	1,885	446	72	138	2,192	20,054	396,607	416,661
	1,728	387	106	230	1,885	28,156	455,683	483,839

PIPE-LINE STATISTICS.

With the statistics furnished by pipe-line and other transporting agencies are incorporated, wherever appropriate and without differentiation, the statistics of fuel consumed in field operations and the statistics of local sales of crude petroleum by producers, concerning which the transportation companies have no record.

APPALACHIAN OIL FIELD.

GENERAL STATEMENT.

The Appalachian field embraces all oil pools east of northwestern Ohio and north of central Alabama, including those of New York, Pennsylvania, West Virginia, southeastern and central Ohio, Kentucky, Tennessee, and northern Alabama. Its total length is about 500 miles and its broadest part centering in eastern Ohio is about 150 miles. The area of greatest oil development occupies a narrower zone which averages less than 50 miles in width and centers in the panhandle of West Virginia.

"The oil and gas bearing sands occur throughout a long stratigraphic interval, including rocks ranging in age from Ordovician to Carboniferous. The strata consist of preponderating shale, lenses of sandstone—which are the main oil and gas reservoirs—and subordinate limestone. The sandstones merge into shales toward the west, where there is also a greater proportion of limestone in the section. There is a marked decrease in thickness of the strata toward the west, notably of the Upper Devonian. This is shown by the increase in the interval between the Berea sandstone and the Corniferous limestone, from 500 feet in central Ohio to more than 5,800 feet in northern West Virginia. To the south across West Virginia there is a notable thickening of the Pottsville formation. For this reason and because of the basin structure of the district the 'Clinton' sandstone, which occurs between 2,000 and 3,000 feet beneath the surface in central Ohio, is more than 7,000 feet deep in western Pennsylvania and

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northern West Virginia, where it was not encountered in two recently sunk very deep test holes.

"The Appalachian oil and gas district lies in the geosyncline that extends between the Cincinnati anticline on the west and the zone of steeply folded rocks of the Allegheny Mountains on the east. The syncline is a spoon-shaped trough in which the rocks rise northwestward, northward, and southeastward from the lowest part of the basin, in West Virginia near the southwest corner of Pennsylvania. Superimposed on this larger structural feature are a series of folds by which the rocks are warped into irregular and generally nonpersistent anticlines and synclines, whose axes undulate and overlap. The axial trend throughout the greater part of the district is northeast, but in southern West Virginia and Kentucky the trend becomes more westward. The folds decrease in intensity westward from the eastern margin of the district, and west of the axis of the geosyncline the folding is so gentle that the rocks are warped into irregular wrinkles without marked axial trend. Along the western margin of the district the folds practically disappear and give way to a monocline on which the rocks rise westward at the rate of about 60 feet to the mile.

"In the region considered as a whole the most productive oil belt is contiguous to the central axis of the geosyncline and the largest accumulations of gas are found along the outer margins of the trough. But pools of oil and gas of varying size separated by nonproductive areas are irregularly distributed throughout the district. The pools are characteristically elongated in outline, and their longer dimensions are prevailingly parallel to the structural trend. The location of most of the gas pools has been distinctly determined by structure. They occur along the crests of anticlines or along the up-dip termination of lenses of sandstone where they merge with shale or where there is a marked decrease in porosity of the pay sand. The influence of structure on oil accumulation is also pronounced. In the absence of gas, some oil pools occur on the crests of anticlines. Where much gas is present the oil pools occur on the flanks of anticlines below the gas and above the edge water; others occur on terraces marked by changes in the rate of dip. In the absence of water in the rocks petroleum tends to occur in the synclines. In many pools, however, the effect of structure is not so evident and lithology has been the controlling factor. The location of many of the oil pools in the Appalachian region is due principally to the position and porosity of the lenticular reservoir rocks. These factors account for the irregular shape of many of the pools and for their not uncommon occurrence 'off structure.'

"The petroleum from the Appalachian region is a high-grade paraffin oil. The product of New York, Ohio, Pennsylvania, and West Virginia has an average specific gravity not far from 0.800 (45° Baumé). The average for Kentucky is not quite so high.

"Extension of the production curve indicates that approximately 85 per cent of the recoverable oil from New York and Pennsylvania has been exhausted under present operating conditions.

"Wells in the Appalachian region are sunk by the standard or churn system of drilling. The rocks are hard and comparatively little casing is required, as contrasted with drilling in the loosely consolidated rocks of other districts. The wells range in depth from a few hundred feet in parts of eastern Ohio and Kentucky to between

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3,000 and 4,000 feet to reach the deeper sands in southern Pennsylvania and West Virginia." [1]

The total output of crude petroleum from the Appalachian field in 1918 was 25,401,466 barrels, a quantity greater by 469,261 barrels, or more than 1 per cent, than the output in 1917. The principal increase in production was in the newer fields of Kentucky. Southeastern Ohio showed a slight increase, but New York, Pennsylvania, and West Virginia showed a normal decline of about 5 per cent.

The average price received at the wells for all grades of Appalachian oil was $3.697 a barrel, a gain of $0.577, or 18 per cent, over the average in 1917. The market value of the oil sold was approximately $93,917,171, a gain of $16,130,676, or about 21 per cent, as compared with the market value of the output in 1917. The quoted market price for Pennsylvania grade of petroleum, which includes the greater part of the oil produced in the Appalachian field, rose on February 8 from $3.75 to $4 a barrel, and maintained this level throughout the year. Other grades showed a corresponding increase.

Activity in drilling was somewhat less in 1918 than in 1917 in the Appalachian field as a whole. In all, 7,203 wells were completed in 1918, a decrease of 467, or 6.1 per cent, from the previous year's record. Of the wells drilled in 1918, 4,872, or 67.6 per cent, were oil wells credited with an average yield of 16.4 barrels each the first day of productive life, 1,068 were gas wells, and 1,263, or 17.5 per cent, were dry holes.

The following tables include essential statistics of the petroleum industry in the Appalachian oil field in 1918 and in other recent years:

PETROLEUM PRODUCED.

Petroleum produced in the Appalachian field in 1917 and 1918, in barrels.

Month.	Pennsylvania.	New York.	Southeastern and central Ohio.	West Virginia.	Kentucky.	Tennessee.	Total.
1917.							
January	641,092	74,332	389,402	700,840	154,378	.....	1,960,044
February	555,525	59,615	352,102	617,115	139,417	797	1,724,571
March	712,735	81,305	415,850	731,373	174,299	1,127	2,116,689
April	672,875	71,511	398,347	669,982	165,331	.....	1,978,046
May	711,358	81,371	430,389	739,808	240,024	1,138	2,204,088
June	686,789	80,232	412,722	684,290	266,328	380	2,130,741
July	670,550	75,270	424,766	684,461	318,776	374	2,174,197
August	665,484	76,836	434,381	704,155	320,529	927	2,202,312
September	610,115	71,247	394,632	702,030	330,626	3,960	2,112,610
October	645,981	74,836	429,751	760,430	352,481	1,650	2,265,129
November	608,631	67,106	401,629	700,231	339,783	1,307	2,118,687
December	552,065	66,024	355,708	684,570	286,188	536	1,945,091
	7,733,200	879,685	4,839,679	8,379,285	3,088,160	12,196	24,932,205
1918.							
January	502,185	48,753	324,683	589,538	265,223	993	1,731,375
February	557,564	57,530	366,058	631,042	287,524	927	1,900,645
March	668,325	73,414	434,727	659,099	322,479	617	2,158,661
April	647,535	68,983	424,969	685,714	312,322	773	2,140,296
May	690,420	77,429	447,544	703,016	316,164	465	2,235,038
June	611,681	68,681	404,764	625,727	305,571	776	2,017,200
July	663,988	70,541	446,774	687,305	355,899	468	2,224,975
August	632,108	72,582	426,177	644,511	383,467	589	2,159,434
September	589,584	70,027	397,027	640,237	415,451	457	2,112,783
October	657,463	67,776	445,492	684,122	448,363	1,078	2,304,294
November	583,933	64,650	396,973	640,551	459,876	767	2,146,750
December	603,026	68,477	426,653	675,766	495,629	464	2,270,015
	7,407,812	808,843	4,941,841	7,866,628	4,367,968	8,374	25,401,466

[1] Manual for the oil and gas industry, under the revenue act of 1918, Treasury Dept., U. S. Bur. Internal Revenue, 1919.

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Petroleum produced in the Appalachian field since 1859.

Year.	Quantity (barrels).	Percentage of total production of United States.	Increase or decrease.		Value.	Yearly average price per barrel.
			Barrels.	Per cent.		
1859	2,000	100.00	.....	.....	$32,000	$16.000
1860	500,000	100.00	+ 498,000	+24,900.00	4,800,000	9.590
1861	2,113,609	100.00	+1,613,609	+ 322.72	1,035,668	.490
1862	3,056,690	100.00	+ 943,081	+ 44.62	3,209,525	1.050
1863	2,611,309	100.00	− 445,381	− 14.57	8,225,663	3.150
1864	2,116,109	100.00	− 495,200	− 18.96	20,896,576	8.060
1865	2,497,700	100.00	+ 381,591	+ 18.03	16,459,853	6.590
1866	3,597,700	100.00	+1,100,000	+ 44.04	13,455,398	3.740
1867	3,347,300	100.00	− 250,400	− 6.96	8,066,993	2.410
1868	3,646,117	100.00	+ 298,817	+ 8.93	13,217,174	3.625
1869	4,215,000	100.00	+ 568,883	+ 15.60	23,730,450	5.638
1870	5,260,745	100.00	+1,045,745	+ 24.81	20,503,754	3.860
1871	5,205,234	100.00	− 55,511	− 1.06	22,591,180	4.340
1872	6,293,194	100.00	+1,087,960	+ 20.90	21,440,503	3.640
1873	9,893,786	100.00	+3,600,592	+ 57.21	18,100,464	1.830
1874	10,926,945	100.00	+1,033,159	+ 10.44	12,647,527	1.170
1875	8,787,514	100.00	−2,139,431	− 19.58	7,368,133	1.350
1876	9,120,669	99.87	+ 333,155	+ 3.79	22,952,822	2.563
1877	13,337,363	99.90	+4,216,694	+ 46.23	31,756,066	2.420
1878	15,381,641	99.90	+2,044,278	+ 15.33	18,009,346	1.190
1879	19,894,288	99.90	+4,512,647	+ 29.34	17,164,536	.859
1880	26,245,571	99.85	+6,351,283	+ 31.93	24,506,963	.945
1881	27,561,376	99.64	+1,315,805	+ 5.01	25,217,612	.915
1882	30,221,261	99.58	+2,659,885	+ 9.65	23,334,016	.772
1883	23,306,776	99.39	−6,914,485	− 22.88	25,460,252	1.092
1884	23,956,438	98.92	+ 649,662	+ 2.79	19,990,746	.834
1885	21,533,785	98.51	−2,422,653	− 10.11	18,447,493	.856
1886	26,549,827	94.60	+5,016,042	+ 23.29	18,681,910	.704
1887	22,878,241	80.90	−3,671,586	− 13.83	16,279,971	.712
1888	16,941,397	61.36	−5,936,844	− 25.95	14,836,701	.876
1889	22,355,225	63.57	+5,413,828	+ 31.96	24,485,407	.941
1890	30,066,560	65.61	+7,711,335	+ 34.50	30,121,968	.868
1891	35,848,777	66.03	+5,782,217	+ 19.23	24,219,863	.670
1892	33,432,377	66.19	−2,416,400	− 6.74	18,830,773	.556
1893	31,365,890	64.76	−2,066,487	− 6.18	20,327,232	.640
1894	30,783,424	62.38	− 582,466	− 1.86	26,030,125	.839
1895	30,960,639	58.54	+ 177,215	+ .58	42,206,898	1.350
1896	33,971,902	55.73	+3,011,263	+ 9.73	40,203,418	1.179
1897	35,230,271	58.25	+1,258,369	+ 3.70	27,877,213	.786
1898	31,717,425	57.29	−3,512,846	− 9.97	29,096,057	.911
1899	33,068,356	57.94	+1,350,931	+ 4.26	43,041,677	1.294
1900	36,295,433	57.05	+3,227,077	+ 9.76	49,235,298	1.353
1901	33,618,171	48.45	−2,677,262	− 7.38	40,796,827	1.210
1902	32,018,787	36.07	−1,599,384	− 4.76	40,451,393	1.238
1903	31,558,248	31.41	− 460,539	− 1.44	49,905,813	1.590
1904	31,408,567	26.83	− 149,681	− .47	50,598,184	1.628
1905	29,366,960	21.80	−2,041,607	− 6.50	40,279,635	1.394
1906	27,741,472	21.93	−1,625,488	− 5.54	43,633,601	1.598
1907	25,342,137	15.26	−2,399,335	− 8.65	43,766,686	1.745
1908	24,945,517	13.97	− 396,620	− 1.57	43,888,020	1.780
1909	26,535,844	14.49	+1,590,327	+ 6.38	43,237,233	1.629
1910	26,892,579	12.83	+ 356,735	+ 1.33	35,841,749	1.333
1911	23,749,832	10.77	−3,142,747	− 11.37	30,830,354	1.298
1912	26,338,516	11.81	+2,588,684	+ 10.90	42,818,384	1.626
1913	25,921,785	10.43	− 416,731	− 1.58	63,708,981	2.458
1914	24,101,048	9.07	−1,820,737	− 7.02	45,239,301	1.877
1915	22,860,048	8.13	−1,241,000	− 5.15	35,468,973	1.552
1916	23,009,455	7.65	+ 149,407	+ .55	56,689,178	2.464
1917	24,932,205	7.44	+1,922,750	+ 8.36	77,786,495	3.120
1918	25,401,466	7.14	+ 469,261	+ 1.88	93,917,171	3.697
	1,221,838,501	26.51	.....	.....	1,746,953,602	1.430

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Petroleum produced, value and average price per barrel in the Appalachian field, 1909–1918.

Year.	Pennsylvania.			New York.			Southeastern and central Ohio.		
	Quantity (barrels).	Value.	Average price per barrel.	Quantity (barrels).	Value.	Average price per barrel.	Quantity (barrels).	Value.	Average price per barrel.
1909.....	9,299,403	$15,424,564	$1.658	1,134,997	$1,878,217	$1.655	4,717,436	$7,773,880	$1.648
1910.....	8,794,062	11,908,914	1.354	1,068,838	1,414,668	1.342	4,822,234	6,469,939	1.342
1911.....	8,248,158	10,894,074	1.321	962,515	1,248,950	1,311	4,281,237	5,591,423	1.306
1912.....	7,837,948	12,886,752	1.644	874,128	1,401,880	1.604	5,013,110	8,177,189	1.631
1913.....	7,917,302	19,690,502	2.487	948,191	2,284,307	2.409	4,964,425	12,229,610	2.463
1914.....	8,170,335	15,573,822	1.906	938,974	1,760,868	1.875	4,809,265	8,937,415	1.858
1915.....	7,838,705	12,431,353	1.586	897,778	1,399,325	1.566	4,431,493	6,760,660	1.526
1916.....	7,592,394	19,149,855	2.522	874,087	2,199,195	2.506	4,608,544	11,245,236	2.440
1917.....	7,733,200	25,154,290	3.253	879,645	2,859,378	3.240	4,839,679	15,472,705	3.197
1918.....	7,407,812	29,606,079	3.997	808,843	3,307,814	4.089	4,941,841	18,042,394	3.651

Year.	West Virginia.			Kentucky-Tennessee.			Total.		
	Quantity (barrels).	Value.	Average price per barrel.	Quantity (barrels).	Value.	Average price per barrel.	Quantity (barrels).	Value.	Average price per barrel.
1909.....	10,745,092	$17,642,283	$1.642	[a] 639,016	$518,299	$0.811	26,535,844	$43,237,233	$1.629
1910.....	11,753,071	15,723,544	1.338	[a] 468,774	324,684	.692	26,892,579	35,841,749	1.333
1911.....	9,795,464	12,767,293	1.303	[a] 472,458	328,614	.695	23,749,832	30,830,354	1.298
1912.....	12,128,962	19,927,721	1.643	[a] 484,368	424,842	.877	26,338,516	42,818,384	1.626
1913.....	11,587,299	28,828,814	2.492	[a] 524,568	675,748	1.288	25,921,785	63,708,981	2.458
1914.....	9,690,083	18,468,540	1.908	[a] 502,441	498,556	.992	24,101,048	45,239,201	1.877
1915.....	9,264,798	14,408,278	1.562	[a] 437,274	418,357	.957	22,840,048	35,468,973	1.553
1916.....	8,731,184	21,914,080	2.510	1,203,246	2,189,812	1.820	23,009,455	56,689,178	2.464
1917.....	8,379,285	27,246,980	3.252	3,100,356	7,062,162	2.278	24,932,205	77,786,495	3.120
1918.....	7,866,628	31,652,018	4.024	4,376,342	11,303,866	2.584	25,401,466	93,917,171	3.697

[a] No production in Tennessee recorded.

Petroleum produced in the Appalachian field in 1914–1918, in barrels.

Month.	1914	1915	1916	1917	1918
January	2,103,509	1,898,525	1,735,045	1,960,044	1,731,375
February	1,773,632	1,833,601	1,675,288	1,724,571	1,900,645
March	2,245,177	2,039,101	1,878,543	2,116,689	2,158,661
April	2,271,018	2,092,542	1,852,473	1,978,046	2,140,295
May	2,131,921	1,882,709	2,035,481	2,204,088	2,235,085
June	2,153,470	1,963,778	1,978,564	2,130,741	2,017,280
July	2,211,697	1,944,675	1,905,241	2,174,197	2,224,975
August	1,216,397	1,864,214	2,084,233	2,202,312	2,159,434
September	1,760,930	1,868,186	1,908,448	2,112,610	2,112,780
October	2,329,973	1,831,468	2,045,396	2,265,129	2,304,296
November	1,895,464	1,787,842	2,004,087	2,118,687	2,146,736
December	2,007,860	1,923,407	1,956,706	1,945,091	2,270,015
	24,101,048	22,860,048	23,099,455	24,932,205	25,401,466

Average daily output of petroleum in the Appalachian field, 1914–1918, in barrels.

Month.	1914	1915	1916	1917	1918
January	67,855	61,243	55,969	63,227	55,851
February	63,344	65,486	57,769	61,592	67,880
March	72,425	65,777	60,590	68,280	69,634
April	75,701	66,751	61,749	65,935	71,343
May	68,772	60,733	65,661	71,099	72,098
June	71,782	65,459	65,952	71,625	67,240
July	71,345	62,731	61,459	70,135	71,773
August	39,239	60,781	65,620	71,042	69,659
September	58,698	62,273	63,615	70,420	70,426
October	75,160	59,080	65,981	73,068	74,332
November	63,182	59,595	66,801	70,623	71,558
December	64,770	62,045	63,120	62,745	73,226
Average	66,030	62,630	62,867	68,316	69,593

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RUNS, DELIVERIES, AND STOCKS.

Pipe-line runs and deliveries to trade of petroleum from the Appalachian field in 1917 and 1918 and stocks at end of each month, in barrels.

Month.	1917			1918		
	Runs.	Deliveries.	Stocks.	Runs.	Deliveries.	Stocks.
Dec. 31, 1916			3,849,544			
January	1,960,044	1,647,718	4,161,870	1,731,375	1,784,382	3,768,499
February	1,724,571	1,897,055	3,989,386	1,900,645	1,699,641	3,969,413
March	2,116,689	2,072,860	4,033,215	2,158,661	2,021,989	4,106,085
April	1,978,046	1,908,872	4,102,389	2,140,296	2,180,003	4,066,378
May	2,204,088	1,785,721	4,520,756	2,235,088	2,300,141	4,001,275
June	2,130,741	2,279,484	4,372,013	2,017,200	2,429,866	3,588,609
July	2,174,197	2,182,206	4,364,004	2,224,975	2,186,297	3,627,287
August	2,202,312	2,164,250	4,402,066	2,159,434	2,245,527	3,541,194
September	2,112,610	2,031,290	4,483,386	2,112,783	2,245,050	3,408,927
October	2,265,129	2,573,508	4,175,007	2,304,294	2,290,666	3,422,555
November	2,118,687	2,270,347	4,023,347	2,146,750	2,132,415	3,436,890
December	1,945,091	2,147,022	3,821,416	2,270,015	2,090,542	3,616,363
	24,932,205	24,960,333		26,401,466	25,606,519	

RUNS.

Pipe-line runs of Appalachian oil in 1917 and 1918, in barrels.

1917.

Month.	National Transit.	Southwest Pennsylvania.	Eureka.	Cumberland.	New York Transit.	Tidewater.
January	214,047	119,028	606,213	150,330	13,831	110,335
February	174,478	102,821	548,979	136,935	11,706	94,605
March	238,786	135,533	649,088	172,452	15,218	123,207
April	226,796	134,165	596,642	162,816	13,738	111,294
May	234,002	128,564	653,960	237,704	15,612	126,155
June	226,859	130,870	598,579	264,488	15,904	122,528
July	220,718	126,050	607,281	309,315	13,874	117,495
August	217,126	125,365	617,710	312,229	14,869	121,850
September	198,964	112,084	545,058	327,857	14,002	108,924
October	210,389	117,273	610,230	348,031	14,033	119,602
November	196,834	112,148	565,668	334,206	12,944	116,266
December	164,012	111,681	545,272	281,474	12,282	106,162
	2,523,011	1,467,582	7,144,680	3,027,836	168,013	1,378,423

Month.	Producers and Refiners.	Emery.	Buckeye Macksburg and Cleveland.	Franklin.	Other lines.	Total.
January	168,580	26,970	283,538	2,932	264,240	1,960,044
February	149,459	23,043	254,666	2,031	225,843	1,724,571
March	172,766	27,866	299,653	2,864	279,256	2,116,689
April	156,439	26,870	291,296	2,236	254,754	1,978,046
May	167,114	29,524	317,708	2,778	280,967	2,204,088
June	160,599	29,021	302,584	2,996	286,403	2,130,741
July	159,057	27,540	314,777	2,711	273,379	2,174,197
August	160,731	28,489	321,884	2,717	279,342	2,202,312
September	149,531	25,882	291,516	2,691	336,101	2,112,610
October	161,309	27,486	318,201	2,893	335,592	2,265,129
November	151,382	25,872	293,374	2,429	308,565	2,118,687
December	136,689	26,237	257,374	2,188	302,720	1,945,091
	1,893,566	323,805	3,545,661	32,466	3,427,162	24,932,205

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Pipe-line runs of Appalachian oil in 1917 and 1918, in barrels—Continued.

1918.

Month.	National Transit.	Southwest Pennsylvania.	Eureka.	Cumberland.	New York Transit.	Tidewater.
January	146,055	101,265	462,581	262,424	9,333	91,285
February	176,415	100,477	515,960	284,995	11,677	100,840
March	217,938	114,097	528,372	316,753	13,868	126,889
April	212,247	110,166	550,475	306,850	13,406	126,394
May	228,563	114,192	567,100	298,021	15,102	124,111
June	192,292	108,012	499,682	280,087	13,250	117,817
July	210,606	112,598	554,579	304,058	14,178	128,236
August	201,275	103,407	524,774	360,586	14,377	126,063
September	186,375	97,941	496,990	395,019	12,415	118,458
October	208,165	106,936	538,603	408,537	14,129	127,655
November	181,288	93,336	485,489	394,111	12,363	111,764
December	188,437	96,472	543,919	423,510	13,252	117,177
	2,349,656	1,258,899	6,267,524	4,034,951	157,350	1,422,769

Month.	Producers and Refiners.	Emery.	Buckeye Macksburg and Cleveland.	Franklin.	Other lines.	Total.
January	117,893	21,187	232,825	720	285,707	1,731,375
February	130,967	23,079	262,755	3,234	290,246	1,900,645
March	146,498	29,318	312,764	3,156	350,028	2,158,661
April	145,999	26,930	300,382	3,184	344,263	2,140,296
May	153,916	29,544	317,454	2,718	374,317	2,235,038
June	136,747	27,108	281,821	2,943	357,441	2,017,200
July	145,837	28,162	308,024	2,687	416,010	2,224,975
August	139,895	a 27,463	294,640	2,689	365,265	2,159,434
September	126,045	26,661	272,571	2,409	381,899	2,112,783
October	144,125	29,190	308,278	2,968	415,708	2,304,294
November	128,239	25,621	270,326	2,761	441,452	2,146,750
December	144,426	26,523	288,015	2,618	425,666	2,270,015
	1,660,587	319,786	3,449,855	32,087	4,448,002	25,401,466

DELIVERIES.

Deliveries to trade by eastern pipe lines [a] *in 1917 and 1918, in barrels.*

1917.

Month.	National Transit.	Southwest Pennsylvania.	Eureka.	Cumberland.	Southern.	Crescent.
January	482,034	182,234	81,138	3,816	256,890	161,619
February	428,904	158,692	88,946	4,175	294,416	101,816
March	382,089	204,012	90,103	3,590	319,889	153,137
April	453,196	156,075	77,720	4,103	378,309	143,988
May	378,223	172,802	83,832	3,618	287,829	148,983
June	379,169	199,905	78,155	3,210	487,631	151,875
July	516,982	153,600	90,480	3,979	572,309	154,661
August	492,047	202,214	84,052	4,453	514,538	174,604
September	533,363	169,309	83,803	38,869	502,900	119,647
October	570,436	215,850	107,341	6,397	550,123	224,556
November	484,264	168,944	111,824	3,004	540,776	137,484
December	441,035	173,715	90,664	5,616	619,187	128,902
	5,541,742	2,157,352	1,068,058	84,820	5,324,797	1,801,272

[a] These pipe lines connect with the delivering lines of the Illinois, Kansas, and Oklahoma fields and receive and transfer large quantities of these western oils to the Atlantic seaboard in addition to the oil from wells directly tributary to their own systems.

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Deliveries to trade by eastern pipe lines in 1917 and 1918, in barrels—Continued.

1917—Continued.

Month.	New York Transit.	Tidewater.	Producers and Refiners.	Emery.	Buckeye Macksburg and Cleveland.	Franklin.
January	737,518	127,869	181,573	24,983	7,675	5,537
February	731,980	116,186	139,594	43,192	5,823	486
March	769,157	155,072	165,503	23,050	7,433	30
April	657,970	151,711	123,739	25,972	6,592	72
May	552,482	127,095	190,359	28,335	7,439	.....
June	643,714	161,265	229,830	30,552	4,386	6,667
July	869,452	174,223	189,059	28,739	2,490	.....
August	769,010	214,800	129,648	19,631	5,070	14,094
September	712,175	86,548	128,487	34,992	2,728	9,488
October	786,678	175,074	229,309	30,657	5,496	10,445
November	809,608	148,573	225,249	25,260	6,711	6,602
December	972,166	95,067	201,313	23,699	7,002	556
	9,001,910	1,733,483	2,133,663	339,062	68,845	53,977

1918.

Month.	National Transit.	Southwest Pennsylvania.	Eureka.	Cumberland.	Southern.	Crescent.
January	459,221	186,377	99,300	998	499,362	108,062
February	331,693	170,462	100,079	2,082	433,917	112,659
March	389,346	184,814	100,632	2,960	514,335	180,430
April	390,093	199,949	96,280	5,527	540,903	198,548
May	425,463	203,845	108,559	3,963	508,798	176,637
June	510,177	213,084	105,987	989	487,803	179,066
July	487,448	163,777	115,084	1,990	537,192	176,467
August	482,752	208,955	104,798	5,966	407,042	172,761
September	468,253	192,413	100,437	2,296	578,050	183,934
October	485,797	171,695	111,384	4,870	681,494	172,882
November	437,274	164,716	105,788	2,514	530,155	160,583
December	454,918	165,538	99,345	931	486,109	169,738
	5,322,435	2,225,625	1,247,673	35,086	6,205,160	1,991,767

Month.	New York Transit.	Tidewater.	Producers and Refiners.	Emery.	Buckeye Macksburg and Cleveland.	Franklin.
January	955,118	105,727	114,469	20,607	2,769	437
February	811,147	78,712	117,755	19,835	3,834	1,059
March	834,096	145,950	141,094	21,250	4,825	816
April	831,066	130,325	174,332	27,809	5,890	6,835
May	931,621	123,682	190,526	37,409	2,645	1
June	971,372	112,855	204,341	28,794	2,861	4
July	891,970	118,851	140,261	28,924	1,926	625
August	862,934	152,313	188,887	27,824	2,651	1,535
September	878,357	103,295	175,889	28,480	7,553	1,583
October	742,951	137,875	171,646	25,908	7,280	4,767
November	737,353	111,330	185,924	27,821	8,913	4,889
December	635,974	77,596	187,619	30,523	5,631	3,120
	10,083,958	1,398,511	1,992,743	325,184	56,778	25,671

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STOCKS.

Stocks of petroleum held by eastern pipe lines in the Appalachian field at the end of each month for 1917 and 1918, in barrels.

1917.

Month.	National Transit.	Southwest Pennsylvania.	Eureka.	Cumberland.	Southern.	Crescent.
January	689,981	590,119	1,408,229	207,006	567,623	74,938
February	765,476	523,137	1,450,145	195,411	595,523	113,540
March	853,856	531,093	1,463,138	222,802	523,418	112,813
April	709,755	545,862	1,429,021	207,690	623,853	126,252
May	826,837	528,403	1,444,379	250,569	692,587	128,519
June	840,560	545,908	1,432,064	253,522	660,275	127,470
July	795,963	646,477	1,353,350	230,797	705,768	126,379
August	861,000	574,541	1,397,643	212,655	674,640	102,441
September	804,419	591,726	1,336,109	202,466	651,571	130,702
October	784,390	681,075	1,308,983	180,509	695,025	62,859
November	784,432	492,225	1,303,198	190,244	734,332	86,583
December	752,113	395,134	1,330,522	147,065	599,662	122,929

Month.	New York Transit.	Tidewater.	Northern.	Producers and Refiners.	Emery.	Buckeye Macksburg and Cleveland.
January	1,259,480	493,313	918,874	337,756	34,486	601,863
February	1,171,789	514,015	797,619	345,682	14,343	489,343
March	1,184,023	488,784	795,803	259,257	19,160	521,252
April	1,012,488	542,856	724,371	290,920	20,057	552,269
May	1,043,571	556,642	586,035	411,259	21,247	515,819
June	1,267,221	567,377	732,690	341,854	11,365	408,125
July	1,422,661	507,390	913,762	341,257	18,516	467,997
August	1,463,989	644,276	1,039,124	366,801	27,373	519,131
September	1,228,602	738,531	1,159,722	380,786	18,263	542,229
October	953,587	684,359	1,151,137	360,423	15,093	360,600
November	1,006,139	822,925	828,470	288,421	15,705	315,260
December	1,109,607	819,931	724,899	275,918	17,242	322,897

Month.	Buckeye Lima.	Indiana.	Franklin.	Other lines.	Total.
January	2,202,582	830,263	31,110	1,010,859	11,258,427
February	2,269,385	822,952	32,655	930,097	11,031,092
March	2,430,786	810,048	35,489	938,772	11,190,674
April	2,424,760	1,031,399	38,684	980,602	11,257,750
May	2,654,411	818,199	41,461	986,968	11,507,406
June	2,565,867	925,623	37,790	1,031,556	11,809,257
July	2,611,419	921,588	40,501	1,012,889	12,117,214
August	2,515,706	904,044	29,124	889,735	12,222,173
September	2,527,878	769,906	22,327	930,001	12,035,637
October	2,443,549	894,671	14,775	978,817	11,569,723
November	2,305,404	907,096	10,602	941,587	11,092,922
December	2,042,633	988,431	12,235	924,641	10,586,389

1918.

Month.	National Transit.	Southwest Pennsylvania.	Eureka.	Cumberland.	Southern.	Crescent.
January	703,241	440,199	1,376,383	141,358	564,459	168,574
February	772,292	464,195	1,322,345	138,966	624,030	138,767
March	813,511	436,733	1,301,374	142,067	561,639	120,077
April	772,934	476,185	1,292,730	143,661	527,825	81,224
May	811,639	495,607	1,245,824	144,379	568,380	80,665
June	702,893	563,600	1,305,080	137,116	517,001	75,369
July	758,146	499,682	1,272,654	124,360	613,903	79,525
August	743,495	466,228	1,341,090	141,952	566,254	87,126
September	716,900	468,709	1,280,143	167,595	649,343	73,977
October	714,332	477,841	1,352,866	195,353	556,907	76,484
November	634,119	501,685	1,343,443	228,793	584,940	80,439
December	699,420	458,684	1,323,168	206,496	629,865	77,075

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Stocks of petroleum held by eastern pipe lines in the Appalachian field at the end of each month for 1917 and 1918, in barrels—Continued.

1918—Continued.

Month.	New York Transit.	Tidewater.	Northern.	Producers and Refiners.	Emery.	Buckeye, Macksburg, and Cleveland.
January	1,100,699	767,172	563,338	281,745	17,822	351,547
February	852,769	773,881	536,311	348,805	21,065	401,775
March	800,342	694,007	541,830	344,274	29,133	485,480
April	853,602	642,447	585,179	369,656	28,255	477,275
May	884,837	617,429	572,770	383,719	20,390	395,258
June	812,186	607,435	576,389	326,523	18,704	269,115
July	952,612	631,091	563,989	311,445	17,942	267,963
August	1,120,042	644,741	578,036	249,003	17,580	258,511
September	816,569	683,540	568,616	242,351	14,761	225,994
October	836,567	701,712	589,652	297,085	18,043	225,639
November	804,502	691,050	559,554	274,276	15,843	238,240
December	737,541	729,543	570,951	285,667	11,844	225,205

Month.	Buckeye Lima.	Indiana.	Franklin.	Other lines.	Total.
January	1,658,451	843,806	12,517	1,405,207	10,396,518
February	1,627,210	741,909	14,692	1,230,590	10,009,602
March	1,684,635	722,614	17,032	1,131,701	9,826,440
April	1,756,798	770,652	13,380	1,065,395	9,857,197
May	1,766,454	832,546	16,098	1,341,125	10,117,120
June	1,719,743	935,167	19,037	1,393,880	9,979,239
July	1,768,083	828,914	21,099	1,193,058	9,904,466
August	1,700,187	783,458	22,252	1,397,131	10,117,086
September	1,670,245	794,024	23,079	1,221,442	9,617,288
October	1,677,821	731,568	21,281	1,182,778	9,655,929
November	1,527,473	750,335	19,153	1,058,705	9,312,450
December	1,627,264	702,699	18,651	942,057	9,246,130

Stocks of all grades of petroleum held by eastern pipe lines [a] in the Appalachian field at end of each month in 1917 and 1918, in barrels.

1917.

Month.	Pennsylvania.[b]	Lima.	Illinois.	Kentucky.	Mid-Continent.	Total.
January	3,726,719	2,276,642	1,205,524	435,151	3,614,391	11,258,427
February	3,539,801	2,338,671	1,216,378	449,585	3,486,657	11,031,092
March	3,589,729	2,489,553	958,799	443,486	3,709,107	11,190,674
April	3,662,200	2,397,305	977,419	440,189	3,780,637	11,257,750
May	3,932,485	2,257,449	733,855	588,271	3,995,346	11,507,406
June	3,802,583	2,167,158	762,394	569,430	4,507,692	11,809,257
July	3,710,473	2,129,019	722,273	653,526	4,901,918	12,117,214
August	3,744,241	2,059,377	628,959	657,825	5,131,771	12,222,173
September	3,767,701	1,909,947	671,251	715,685	4,971,053	12,035,637
October	3,465,012	1,920,604	743,178	709,995	4,730,934	11,569,723
November	3,286,319	1,981,655	829,297	737,028	4,258,623	11,092,922
December	3,229,901	1,906,241	502,312	591,515	4,356,420	10,586,389

1918.

January	3,287,927	1,706,365	970,878	480,482	3,950,866	10,396,518
February	3,830,447	1,489,933	1,013,878	138,966	3,536,378	10,009,602
March	3,509,229	1,468,163	800,380	586,856	3,451,821	9,826,449
April	3,518,036	1,462,455	491,149	548,342	3,837,215	9,857,197
May	3,476,817	1,462,216	533,312	524,458	4,120,317	10,117,120
June	3,075,349	1,332,974	654,656	513,260	4,403,000	9,979,239
July	3,101,500	1,266,459	664,374	525,787	4,346,346	9,904,466
August	2,974,094	1,214,028	814,430	567,100	4,547,434	10,117,086
September	2,731,787	1,136,953	714,683	677,140	4,356,725	9,617,288
October	2,784,476	1,120,438	723,641	638,079	4,389,295	9,655,929
November	2,753,845	1,053,172	552,764	683,045	4,269,624	9,312,450
December	2,858,586	1,028,808	424,604	757,777	4,176,355	9,246,130

[a] These pipe lines connect with the delivering lines of the Illinois, Kansas, and Oklahoma fields and receive and transfer large quantities of these western oils to the Atlantic seaboard in addition to the oil from the wells directly tributary to their own systems.

[b] Includes natural lubricating oil from Pennsylvania and West Virginia.

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PRICES OF APPALACHIAN OIL.

Prices paid at wells by the Seep Purchasing Agency for petroleum produced in the Appalachian field in 1917 and 1918.

1917.

Date.	Pennsylvania and Tiona, Pa.	Mercer black, Pa.	Corning, Ohio.	Cleveland, Ohio.	Wooster, Ohio.	Cabell, W. Va.	Somerset, Ky. (light).	Ragland, Ky. (heavy).
Jan. 1	$2.85	$2.30	$2.25	$2.20	$1.80	$2.22	$2.05	$0.95
Jan. 2					1.90			
Jan. 5	2.95	2.35	2.30			2.27	2.10	.97
Jan. 8					2.00			
Jan. 9	3.05	2.43	2.38			2.35	2.18	1.00
Jan. 30				2.25	2.05			
Apr. 16				2.30	2.10			
Apr. 17	3.10	2.45	2.40			2.37	2.20	
May 1								
May 15		2.18		2.38	2.18			
Aug. 13	3.25	2.23	2.50			2.47	2.30	1.10
Aug. 16				2.58	2.38			
Aug. 20	3.50		2.60			2.57	2.40	
Dec. 4	3.75		2.80			2.72	2.55	1.20

1918.

Jan. 1	$3.75		$2.80	$2.58	$2.38	$2.72	$2.55	$1.20
Feb. 8	4.00		2.85			2.77	2.60	1.25
Feb. 9				2.68	2.48			
Mar. 21				2.78	2.58			

NOTE.—In addition to these prices bonuses ranging from 2 to 25 cents a barrel were paid by various pipe lines and refineries.

Average monthly prices of Appalachian petroleum in 1917 and 1918.

1917.

Month.	Pennsylvania and Tiona, Pa.	Mercer black, Pa.	Corning, Ohio.	Cleveland, Ohio.	Wooster, Ohio.	Cabell, W. Va.	Somerset, Ky.	Ragland, Ky.
January	$3.01	$2.40	$2.29	$2.20	$1.96	$2.32	$2.15	$0.99
February	3.05	2.43	2.38	2.25	2.05	2.35	2.18	1.00
March	3.05	2.43	2.38	2.25	2.05	2.35	2.18	1.00
April	3.07	2.44	2.39	2.28	2.08	2.36	2.19	1.00
May	3.10	2.30	2.40	2.38	2.14	2.37	2.20	1.00
June	3.10	2.18	2.40	2.38	2.18	2.37	2.20	1.00
July	3.10	2.18	2.40	2.38	2.18	2.37	2.20	1.00
August	3.29	2.21	2.50	2.48	2.28	2.47	2.30	1.06
September	3.50	2.23	2.60	2.58	2.38	2.57	2.40	1.10
October	3.50	2.23	2.60	2.58	2.38	2.57	2.40	1.10
November	3.50	2.23	2.60	2.58	2.38	2.57	2.40	1.10
December	3.73	2.23	2.72	2.58	2.38	2.71	2.54	1.10
Average	3.25	2.29	2.62	2.41	2.21	2.45	2.28	1.05

1918.

Month.	Pennsylvania and Tiona, Pa.	Corning, Ohio.	Cleveland, Ohio.	Wooster, Ohio.	Cabell, W. Va.	Somerset, Ky.	Ragland, Ky.
January	$3.75	$2.80	$2.58	$2.38	$2.72	$2.55	$1.20
February	3.94	2.84	2.65	2.45	2.76	2.59	1.24
March	4.00	2.85	2.72	2.52	2.77	2.60	1.25
April	4.00	2.85	2.78	2.58	2.77	2.60	1.25
May	4.00	2.85	2.78	2.58	2.77	2.60	1.25
June	4.00	2.85	2.78	2.58	2.77	2.60	1.25
August	4.00	2.85	2.78	2.58	2.77	2.60	1.25
September	4.00	2.85	2.78	2.58	2.77	2.60	1.25
October	4.00	2.85	2.78	2.58	2.77	2.60	1.25
November	4.00	2.85	2.78	2.58	2.77	2.60	1.25
December	4.00	2.85	2.78	2.58	2.77	2.60	1.25
Average	3.97	2.84	2.75	2.55	2.76	2.59	1.24

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Monthly and yearly average prices of pipe-line certificates of petroleum of Pennsylvania grade at wells in daily market, 1909–1918, per barrel.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average.
1909	$1.78	$1.78	$1.78	$1.78	$1.70	$1.67½	$1.60½	$1.58	$1.58	$1.56½	$1.49	$1.44½	$1.646
1910	1.40½	1.40	1.40	1.36½	1.35	1.31½	1.30	1.30	1.30	1.30	1.30	1.30	1.336
1911	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.31	1.301
1912	1.41	1.50	1.50	1.52	1.55	1.59	1.60	1.60	1.60	1.60	1.75	1.96	1.598
1913	2.07	2.49	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.463
1914	2.50	2.50	2.50	2.37	1.93	1.78	1.72	1.54	1.45	1.45	1.45	1.45	1.889
1915	1.50	1.50	1.45	1.35	1.35	1.35	1.35	1.47	1.64	1.75	1.91	2.12	1.566
1916	2.26	2.37	2.53	2.60	2.60	2.60	2.59	2.34	2.31	2.51	2.60	2.74	2.507
1917	3.01	3.05	3.05	3.07	3.10	3.10	3.10	3.29	3.50	3.50	3.50	3.73	3.260
1918	3.75	3.94	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	3.974

Highest and lowest prices of crude petroleum of Pennsylvania grade, 1859–1918, per barrel.

Year.	Highest.		Lowest.	
	Month.	Price.	Month.	Price.
1859	September	$20.00	December	$20.00
1860	January	20.00	.....do	2.00
1861	.....do	1.75	.....do	.10
1862	December	2.50	January	.10
1863	.....do	4.00	.....do	2.00
1864	July	14.00	February	3.75
1865	January	10.00	August	4.00
1866	.....do	5.50	December	1.35
1867	October	4.00	June	1.50
1868	July	5.75	January	1.70
1869	January	7.00	December	4.25
1870	.....do	4.90	August	2.75
1871	June	5.25	January	3.25
1872	October	4.55	December	2.67½
1873	January	2.75	November	.82½
1874	February	2.25	.....do	.62½
1875	.....do	1.82½	January	.75
1876	December	4.23½	.....do	1.47½
1877	January	3.69½	June	1.53½
1878	February	1.87½	September	.78½
1879	December	1.28½	June	.63½
1880	June	1.24½	April	.71½
1881	September	1.01½	July	.72½
1882	November	1.37	.....do	.49½
1883	June	1.21½	January	.83½
1884	January	1.15½	June	.51½
1885	October	1.12½	January	.68
1886	January	.92½	August	.59½
1887	December	.90	July	.54
1888	March	1.00	June	.71½
1889	November	1.12½	April	.79½
1890	January	1.07½	December	.60½
1891	February	.81½	August	.50
1892	January	.64½	October	.50
1893	December	.80	January	.52½
1894	.....do	.95½	.....do	.78½
1895	April	2.60	.....do	.95½
1896	January	1.50	December	.90
1897	March	.96	October	.65
1898	December	1.19	January	.65
1899	.....do	1.66	February	1.13
1900	January	1.68	November	1.05
1901	January, September	1.45	May	.80
1902	December	1.54	January, February, March	1.15
1903	.....do	1.90	January, February, March, April, May, June, July.	1.50
1904	January	1.85	July, December	1.50
1905	October	1.61	May	1.27
1906	April, May, June, July	1.64	January, February, March, April, August, September, October, November, December.	1.58
1907	March to December, inclusive.	1.78	January	1.58
1908	No change	1.78	No change	1.78
1909	January, February, March	1.78	December	1.43
1910	January	1.43	June to December, inclusive	1.30
1911	December	1.35	January to December	1.30
1912	.....do	2.00	January	1.35
1913	March to December, inclusive.	2.50	.....do	2.00
1914	January to March, inclusive	2.50	September to December, inclusive	1.45
1915	December	2.25	April to August, inclusive	1.35
1916	.....do	2.85	January	2.25
1917	.....do	3.75	.....do	2.85
1918	February to December, inclusive.	4.00	.....do	3.75

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SUMMARY OF WELLS DRILLED IN APPALACHIAN FIELD.

The statistics of field operations presented in the following tables are compiled from trade-journal sources and differ somewhat from those on pages 984–990, which were taken from reports received directly from the oil producers.

Wells completed in the Appalachian field, 1914–1918.

State.	Oil.					Dry.					Total completed.[a]				
	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918
Pennsylvania and New York	2,247	1,409	2,500	1,936	1,577	338	284	296	356	219	2,869	1,906	3,051	2,558	2,008
Southeastern and central Ohio	863	677	927	868	803	517	472	525	564	446	2,044	1,910	1,854	1,828	1,695
West Virginia	1,043	763	1,055	933	741	347	246	296	267	240	1,758	1,288	1,793	1,635	1,310
Kentucky	119	56	878	1,162	1,737	55	36	179	417	252	178	92	1,074	1,638	2,167
Tennessee	.....	4	2	8	14	.....	7	7	.....	6	.....	12	9	11	23
	4,272	2,909	5,362	4,907	4,872	1,257	1,045	1,303	1,544	1,263	6,849	5,209	7,781	7,670	7,203

[a] Including gas wells.

Oil wells and dry holes drilled in the Appalachian field in 1918.

State.	Jan.		Feb.		Mar.		Apr.		May.		June.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Pennsylvania and New York	59	9	59	9	105	16	128	26	151	26	165	25
Southeastern and central Ohio	30	14	36	28	45	26	69	48	80	48	93	48
West Virginia	35	19	37	9	61	18	66	19	62	20	69	16
Kentucky	54	17	75	23	114	34	146	28	140	27	130	25
Tennessee	.....	.....	.....	2	.....	.....	3	.....	.....	.....	1	.....
	178	59	207	66	325	104	412	121	433	121	458	114

State.	July.		Aug.		Sept.		Oct.		Nov.		Dec.		Total.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Pennsylvania and New York	170	26	158	19	157	7	157	19	132	13	126	23	1,577	219
Southeastern and central Ohio	79	46	76	35	76	41	83	30	69	36	67	41	803	446
West Virginia	67	22	76	24	71	27	73	25	69	21	55	20	741	269
Kentucky	209	38	174	30	179	30	165	38	135	34	216	27	1,737	352
Tennessee	.....	.....	.....	.....	8	2	1	.....	1	2	.....	.....	14	6
	525	132	484	108	491	107	479	112	406	106	474	111	4,872	1,293

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Wells completed in the Appalachian field, 1914–1918.

Month.	Oil.					Dry.					Total completed.[a]				
	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918
January	445	185	323	365	178	117	89	87	103	59	649	468	503	552	316
February	394	364	312	342	207	123	74	82	94	66	574	367	495	538	330
March	321	211	276	382	325	88	84	87	117	104	464	395	439	600	491
April	524	224	351	409	412	137	75	102	116	121	734	390	514	629	598
May	531	237	463	464	433	141	87	121	139	121	770	407	609	711	668
June	489	214	504	473	458	135	83	119	167	116	734	382	723	748	682
July	463	237	591	404	525	121	88	129	141	132	738	411	812	652	746
August	375	251	538	429	484	113	104	127	143	108	615	455	773	682	699
September	198	298	524	423	491	76	84	128	134	107	427	415	703	658	706
October	197	312	541	429	479	70	86	100	125	112	388	508	731	657	692
November	177	337	461	460	406	69	113	103	142	106	385	588	683	722	620
December	188	299	478	327	474	57	78	118	105	111	371	483	687	521	671
	4,272	2,909	5,362	4,907	4,872	1,257	1,045	1,303	1,544	1,263	6,849	5,209	7,781	7,670	7,203

[a] Including gas wells.

Initial daily production of new wells in the Appalachian field in 1918, in barrels.

State.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Pennsylvania and New York	138	214	326	490	349	417	444	497	552	423	416	355	4,621
Southeastern and central Ohio	459	835	408	1,102	1,398	1,681	1,202	975	1,068	1,508	1,139	934	12,019
West Virginia	413	1,007	835	724	676	880	733	3,660	1,399	1,245	2,573	777	14,762
Kentucky	718	1,930	1,694	2,142	2,031	2,553	4,429	4,802	6,037	5,693	6,391	10,201	48,621
Tennessee	.....	.....	.....	90	.....	3	.....	.....	155	5	5	.....	258
	1,728	3,986	3,263	4,548	4,364	4,934	6,807	9,874	9,112	8,874	10,524	12,267	80,281

Total and average initial daily production of new wells in the Appalachian field, 1914–1918, by States, in barrels.

State.	Total initial production.					Average per well.				
	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918
Pennsylvania and New York	6,627	9,320	10,774	9,760	4,621	3.0	6.6	4.3	5.0	2.9
Southeastern and central Ohio	12,047	8,373	10,838	11,976	12,019	14.0	12.4	11.7	13.8	15.0
West Virginia	24,474	13,501	24,234	14,867	14,762	23.5	17.7	23.0	15.9	19.9
Kentucky	1,568	728	27,310	25,293	48,621	13.2	13.0	31.1	30.4	28.0
Tennessee	.....	290	45	615	258	.....	62.5	22.5	76.9	18.4
	44,716	32,172	73,201	72,511	80,281	10.5	11.1	13.7	14.8	16.4

Total initial daily production of new wells in the Appalachian field, 1914–1918, by months, in barrels.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.	Monthly average.
1914	4,787	4,256	4,452	4,190	5,141	4,312	4,102	3,420	2,256	3,776	1,976	2,048	44,716	3,726
1915	2,587	1,794	2,445	2,640	2,433	2,523	3,283	3,677	2,697	2,348	3,731	3,014	31,922	2,660
1916	3,125	3,475	2,381	5,062	4,023	6,052	7,314	6,730	6,737	8,967	8,701	10,054	73,201	6,100
1917	5,499	7,757	7,845	8,236	8,277	4,689	5,535	4,863	5,204	5,445	4,921	4,241	72,511	6,042
1918	1,728	3,986	3,263	4,548	4,364	4,934	6,807	9,874	9,112	8,874	10,524	12,267	80,281	6,690

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PENNSYLVANIA.

GENERAL STATEMENT.

The output of petroleum in 1918 credited to Pennsylvania was 7,407,812 barrels, a decrease of 325,388 barrels, or 4 per cent, compared with the output in 1917. The records for Pennsylvania show a retrograde movement in practically all phases of the industry except value—a decrease in production, in number of wells drilled, and a very marked decrease in the average initial production of new wells. The decline in the percentage of dry holes, as compared with 1917, and in the number of wells of 100 barrels or more of initial capacity shows a marked decline in efforts to discover new territory. The average price received at the wells for all grades of oil produced in Pennsylvania in 1918 was $3.997 a barrel and the total market value of the oil produced was $29,606,079, a gain of 74.4 cents in average unit price and of $4,451,789 in gross market value, as compared with 1917. The posted price for Pennsylvania grade oil rose on February 8 from $3.75 to $4 a barrel, but it was undoubtedly the influence of the oil division of the Fuel Administration which prevented further rise in price.

DEVELOPMENT.

Inclusive of the New York portion of the Bradford district, 1,837 new wells were drilled for oil in Pennsylvania in 1918, a loss of 539 wells, or 23 per cent, as compared with 1917. Of these, 1,423, or 77 per cent, were completed as oil wells and credited with an average yield of 3 barrels each during the first day of productive life, 202 were gas wells, and 212, an average of 1 in every 9 drilled, were failures.

No new pools of importance were discovered in Pennsylvania during the year 1918, development work being confined largely to intensive development of proved territory.

The old Bradford district alone of the Pennsylvania fields showed an increase in number of new wells drilled. There was, however, a decrease in initial production of new wells and an increase in the percentage of dry holes.

The investigations of the Internal Revenue Bureau show that a fair average production for the Bradford district is a quarter of a barrel per well per day but that the wells have an exceptionally long life. The recent introduction of the so-called water drive, which consists of the flooding of certain wells with water in order to increase the production of near-by wells is reported to have met with great success.

It is noteworthy that only 2 to 3 per cent of the wells drilled in this district in recent years are dry holes.

The middle district, embracing the areas of oil production in Warren, Elk, and Forest counties and the Venango-Clarion-Jefferson district both show an increase in the average initial production of new wells but a marked decrease in total number of wells completed. In 1918, 11.5 per cent of the wells drilled in the middle district and 9.5 per cent of the wells in the Venango-Clarion district were dry holes, results not markedly different from the results of efforts in other recent years.

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In Butler and Armstrong counties less than half as many new wells were drilled in 1918 as in 1917. There was also a considerable reduction in average initial output. The only favorable feature was a considerable decrease in the percentage of dry holes—19.7 per cent in 1918, as compared with 23.6 per cent in 1917.

In the southwestern district results were still more discouraging. The average initial production of new wells drilled was only 7.6 barrels, as compared with 20 barrels in 1917. A marked decrease in the number of wells drilled with a considerable decrease in the proportion of dry holes shows the general falling off in efforts to find new productive territory.

Field work in the Pennsylvania and New York districts was more unsatisfactory during 1918 than for a decade. Material was scarce, prices high, and experienced drillers and tool dressers were scarce. The work throughout the year was of the most routine character. Very few wells of important size were obtained and the work was practically confined to old leases. One unexpectedly rich spot was found at Pioneer on Oil Creek, which was originally drilled in the sixties. Several good wells in Clarion County were brought in by the Peoples Natural Gas Co. on the Dwyer Farm, in Red Bank Township, and by other companies on adjacent farms. A revival of interest in Warren County was occasioned by the bringing in of good wells by the Interior Oil & Gas Co. near Deerlick field, northwest of Sheffield.

Only 15 wells having an initial output of 100 barrels or more are reported in Pennsylvania in 1918. Of these 9 were in Greene County, 4 in Allegheny County, and 2 in Clarion County. The largest well reported was No. 4 of the Manufacturers Heat & Light Co., on the Strope tract in Greene County, which started with an initial production at the rate of 280 barrels per day.

NEW YORK.

The production of petroleum from the old pools in New York showed a normal decrease of 8 per cent, which is correlative with a 6 per cent decrease in the number of wells drilled in the Allegany district. Work in these old pools was of a routine nature and resulted in the drilling of 171 wells in the Allegany district, of which 154 were oil wells with an average initial daily production of 1.8 barrels, 10 were gas wells, and 7, or more than 1 in 25, were failures. The percentage of dry holes was larger and the average initial production less than in other recent years.

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COMBINED STATISTICS OF PENNSYLVANIA AND NEW YORK FIELDS.

PETROLEUM PRODUCED.

Petroleum produced in Pennsylvania and New York, 1914–1918, in barrels.

Pennsylvania.

Month.	1914	1915	1916	1917	1918
January	677,284	629,586	625,720	641,092	502,195
February	532,826	615,005	555,410	555,525	557,564
March	726,605	672,343	625,987	712,735	668,325
April	782,378	697,036	662,241	672,875	647,535
May	701,685	638,490	701,435	711,358	690,420
June	724,172	683,410	658,195	686,789	611,681
July	731,080	662,383	641,148	670,559	663,998
August	646,412	655,242	663,901	665,484	632,108
September	688,761	654,036	609,754	610,115	589,564
October	704,024	645,333	638,244	645,981	657,405
November	614,126	623,955	605,049	608,631	583,933
December	640,982	641,684	605,310	552,965	606,026
	8,170,335	7,838,705	7,592,394	7,783,200	7,407,812

New York.

January	78,988	74,101	72,216	74,382	48,733
February	62,424	67,755	61,611	59,615	57,530
March	80,660	79,840	64,909	81,305	73,414
April	88,208	79,018	79,439	71,511	68,988
May	84,548	75,114	80,140	81,371	77,429
June	84,110	76,408	78,586	80,282	68,681
July	84,783	79,012	76,499	75,270	70,541
August	75,512	72,531	76,552	76,836	72,582
September	76,102	72,914	72,946	71,247	70,927
October	81,569	72,399	73,056	74,836	67,776
November	71,563	66,218	68,351	67,705	64,650
December	70,429	72,403	69,792	66,094	68,477
	938,974	887,778	874,097	879,695	808,843

SUMMARY OF WELLS DRILLED.

The statistics of field operations presented in the following tables are compiled from trade-journal sources and differ somewhat from those on page 985, which are obtained from reports received directly from the oil producers.

Wells completed in Pennsylvania and New York, 1914–1918.

District.	Oil.					Dry.					Total completed.a				
	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918
Allegany	215	76	202	160	154	17	4	9	4	7	267	98	224	182	171
Bradford	455	313	485	443	475	28	11	11	10	15	531	348	509	469	491
Middle	207	159	234	219	196	17	16	20	34	30	230	182	262	288	262
Venango and Clarion	813	458	955	644	466	68	66	83	82	52	936	595	1,105	768	546
Butler and Armstrong	183	224	239	168	88	81	84	57	62	25	234	324	339	263	127
Southwestern Pennsylvania	374	179	385	302	198	127	103	116	164	90	621	359	612	588	411
	2,247	1,409	2,500	1,936	1,577	338	284	296	356	219	2,869	1,906	3,051	2,558	2,008

a Including gas wells.

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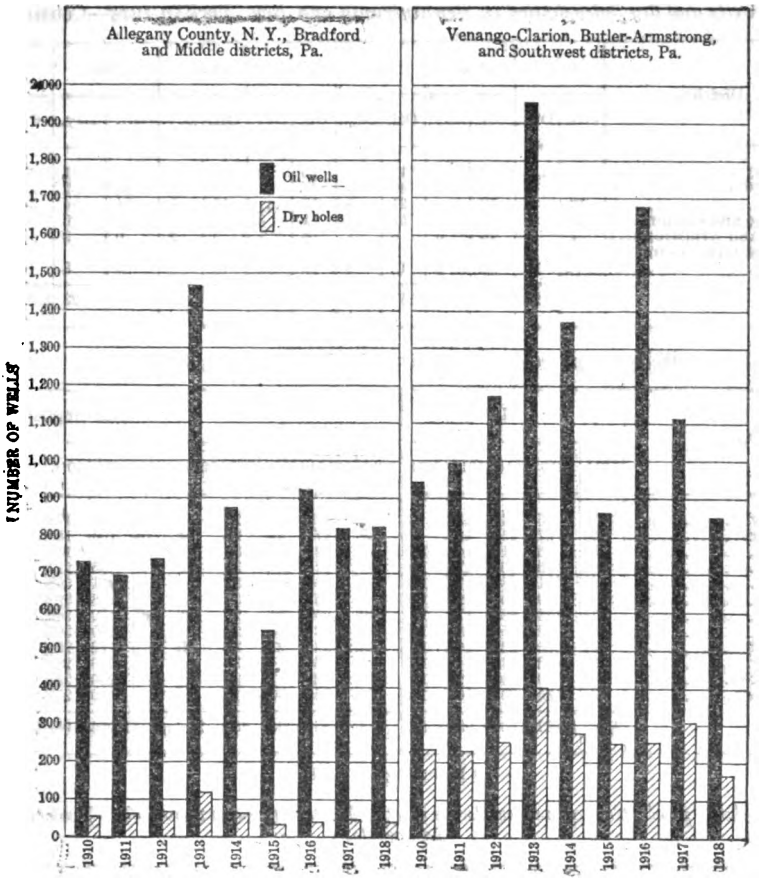

FIGURE 102.—Comparison of number of producing oil wells with dry holes drilled in Pennsylvania and New York, 1910–1918.

Oil wells and dry holes drilled in Pennsylvania and New York in 1918.

District.	Jan.		Feb.		Mar.		Apr.		May.		June.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Allegany	3	1	3	.....	9	.....	15	.....	17	.....	12	1
Bradford	16	.....	9	.....	28	2	37	1	49	2	51	1
Middle	6	1	13	.....	18	5	15	8	18	4	19	1
Venango and Clarion	24	3	17	2	28	3	37	5	40	9	48	5
Butler and Armstrong	2	.....	5	2	8	3	10	4	10	1	8	5
Southwestern Pennsylvania	8	4	12	5	14	3	14	8	17	10	27	13
	59	9	59	9	105	16	128	26	151	26	165	26

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Oil wells and dry holes drilled in Pennsylvania and New York in 1918—Continued.

District.	July.		Aug.		Sept.		Oct.		Nov.		Dec.		Total.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Allegany	26	.....	16	1	15	1	10	2	13	.....	15	1	154	7
Bradford	51	2	52	2	49	.....	45	2	44	1	44	2	475	15
Middle	18	5	18	.....	21	1	17	.....	19	1	14	4	196	30
Venango and Clarion	53	8	44	5	51	.....	51	3	36	3	37	6	466	52
Butler and Armstrong	7	1	13	3	6	1	8	1	5	2	6	2	88	25
Southwestern Pennsylvania	15	10	15	8	15	4	26	11	15	6	20	8	198	90
	170	26	158	19	157	7	157	19	132	13	136	23	1,577	219

Wells completed in Pennsylvania and New York, 1914–1918.

Month.	Oil.					Dry.					Total completed.[a]				
	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918
January	220	75	143	155	59	29	18	21	23	9	271	104	178	196	78
February	164	67	152	124	59	37	17	23	25	9	216	103	186	171	79
March	139	95	115	146	105	24	14	24	32	16	179	114	155	196	134
April	303	105	164	173	128	39	17	29	37	26	355	135	213	235	167
May	286	101	237	176	151	42	26	26	35	26	366	151	293	232	208
June	286	99	267	183	165	42	24	28	34	26	356	138	322	238	216
July	273	123	238	177	170	30	29	30	28	26	340	172	340	230	214
August	209	132	256	187	158	22	33	27	28	19	261	190	305	248	193
September	115	116	231	161	157	24	38	21	32	7	163	172	271	215	188
October	94	182	236	149	157	18	26	14	35	19	133	228	281	200	197
November	83	179	208	197	132	17	28	17	32	13	123	230	248	256	165
December	75	135	203	108	136	14	14	36	15	23	106	169	259	141	174
	2,247	1,409	2,500	1,936	1,597	338	284	296	356	219	2,809	1,906	3,051	2,558	2,008

[a] Including gas wells.

Initial daily production of new wells completed in Pennsylvania and New York in 1918, in barrels.

District.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Allegany	6	5	14	49	33	20	41	26	22	15	23	28	282
Bradford	36	28	97	125	131	104	150	131	158	111	96	132	1,299
Middle	9	22	47	25	30	29	23	25	29	58	123	25	445
Venango and Clarion	43	35	40	64	63	66	123	164	78	70	56	63	865
Butler and Armstrong	11	10	14	19	21	25	12	32	32	21	19	10	226
Southwestern Pennsylvania	33	114	114	208	71	173	95	119	233	148	99	97	1,504
	138	214	326	490	349	417	444	497	552	423	416	355	4,621

Total and average initial daily production of new wells in Pennsylvania and New York, 1914–1918, by districts, in barrels.

District.	Total initial production.					Average per well.				
	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918
Allegany	446	122	407	336	282	2.1	1.6	2.0	2.1	1.8
Bradford	1,588	1,019	1,596	1,390	1,299	3.5	3.3	3.3	3.1	2.7
Middle	586	354	421	381	445	2.8	2.2	1.8	1.7	2.3
Venango and Clarion	1,263	629	1,584	1,127	865	1.6	1.4	1.7	1.8	1.9
Butler and Armstrong	684	4,288	713	500	226	3.7	19.1	3.0	3.0	2.6
Southwestern Pennsylvania	2,060	2,908	6,053	6,026	1,504	5.5	16.2	15.7	20.0	7.6
	6,627	9,320	10,774	9,760	4,621	2.9	6.6	4.3	5.0	2.9

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Total initial daily production of new wells in Pennsylvania and New York, 1914–1918, by months, in barrels.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.	Monthly average.
1914.....	618	527	476	928	764	706	741	727	300	247	334	259	6,627	552
1915.....	208	216	234	275	405	969	1,527	1,726	830	921	1,440	569	9,320	777
1916.....	814	1,429	348	924	632	754	775	740	578	964	510	2,306	10,774	898
1917.....	617	536	1,257	1,912	527	720	1,150	662	417	454	559	949	9,760	813
1918.....	138	214	326	490	349	417	444	497	552	423	416	355	4,621	385

WEST VIRGINIA.

GENERAL STATEMENT.

The quantity of petroleum produced in West Virginia in 1918 was 7,866,628 barrels, a decrease of 512,657, or 6.12 per cent, as compared with 1917. This loss, like that in other recent years, is attributed to a rather marked decline in drilling activity, a general failure of wildcat operations to discover new fields of consequence, and to the normal decrease in production of the older pools.

DEVELOPMENT.

The field work done in West Virginia in 1918 included drilling in 18 counties and resulted in the completion of 1,310 new wells, 325 less than in 1917. Of the wells completed, 741 were oil wells with an initial daily output of 19.9 barrels, 329 produced only gas, and 240 were dry holes. The totals for the State show a marked increase in average initial production and an increase from 16.3 to 18.3 per cent in the percentage of dry holes to total number of wells drilled.

Marion County, as in other recent years, led in the number of new wells drilled but Kanawha County made by far the best showing with 102 oil wells having an average initial daily production of 84 barrels, the best record for any county in West Virginia since 1912. More than half of the new production in the State came from this county.

Boone County was added to the list of oil-producing counties in 1918 with 6 new wells drilled, 5 of which were oil wells with an average initial daily production of 14.6 barrels.

The scarcity and high cost of material and labor almost stopped wildcat operations in West Virginia during the year. The one pool that attracted any considerable attention was discovered at Kellys Creek, Cabin Creek district, Kanawha County, where the Columbia Carbon Co. deepened a gas well to the Weir sand to obtain if possible an increase in gas pressure and obtained an oil well with initial flow reported at more than 400 barrels for the first day of productive life. This discovery started an intense town-lot development, and it was estimated that at one time the production from the pool was very nearly 3,000 barrels a day. The decline, however, was rapid, the producing wells being confined to a very small acreage. The grade of crude at Kellys Creek, like that of Cabin Creek, is very high and commands a premium over the regular market price of Pennsylvania grade.

On Little Creek, in Wetzel County, a well drilled in the early spring started producing about 70 barrels a day and was regarded as the forerunner of a new pool. Further drilling, however, resulted chiefly in dry holes.

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On the Ella Kinsey farm in Mannington district, Marion County, the Hope Natural Gas Co. obtained a good well in the Gordon sand, which, it was hoped, would open up an extension of the Dents Run pool, but further drilling in this vicinity resulted in more dry holes than producers.

Important deep tests in West Virginia have been drilled by the Hope Natural Gas Co. In May it was reported that the deep test in the old Volcano pool near Volcano, Wood County, found a show of oil at 4,445 feet in sand said by Dr. I. C. White to be the Oriskany. The oil was black and heavy and resembled lubricating oil.

The end of October marked the abandonment by this company of the deep test on the M. O. Goff farm in Simpson district, near Clarksburg, Harrison County. This well was drilled on the Chestnut Ridge anticline and reached the extreme depth of 7,386 feet and when finally abandoned was the deepest well in the world. Another deep test was being drilled at the end of the year by the same company on the J. H. Lake farm, near Fairmont, Marion County.

PETROLEUM PRODUCED.

Petroleum produced in West Virginia, 1914–1918, in barrels.

Month.	1914	1915	1916	1917	1918
January	855,886	777,702	647,905	700,840	589,538
February	770,300	754,034	672,843	617,115	631,042
March	919,377	848,926	751,018	731,373	659,099
April	900,998	801,046	674,056	669,982	685,714
May	864,519	767,685	765,938	739,808	703,016
June	872,074	789,545	737,701	684,290	625,727
July	897,065	780,749	704,071	684,461	687,305
August	272,098	761,111	749,831	704,155	644,511
September	675,518	752,751	706,416	702,030	640,237
October	965,724	716,638	783,475	760,430	684,122
November	799,728	720,267	786,723	700,231	640,551
December	866,746	794,344	751,257	684,570	675,726
	9,660,033	9,264,798	8,731,184	8,379,285	7,866,628

Petroleum produced in West Virginia, 1909–1918, in barrels.

Year.	Regular crude.			Lubricating.			Total.		
	Quantity (barrels).	Value.	Average price per barrel.	Quantity (barrels).	Value.	Average price per barrel.	Quantity (barrels).	Value.	Average price per barrel.
1909	10,742,026	$17,634,335	$1.642	3,066	$7,948	$2.59	10,745,092	$17,642,283	$1.642
1910	11,751,018	15,717,796	1.338	2,053	5,748	2.80	11,753,071	15,723,544	1.338
1911	9,792,324	12,757,861	1.302	3,140	9,432	3.00	9,795,464	12,767,293	1.303
1912	12,126,137	19,919,952	1.643	2,825	7,769	2.75	12,128,962	19,927,721	1.643
1913	11,562,730	28,813,832	2.492	4,569	14,982	3.28	11,567,299	28,828,814	2.492
1914	9,677,553	18,462,175	1.908	2,480	6,365	2.56	9,680,033	18,468,540	1.908
1915	9,260,914	14,458,513	1.561	3,884	9,765	2.51	9,264,798	14,468,278	1.561
1916	8,727,930	21,904,236	2.510	3,254	9,844	3.03	8,731,184	21,914,080	2.510
1917	8,377,697	27,240,608	3.252	1,588	6,352	4.00	8,379,285	27,246,960	3.252
1918	7,864,630	31,643,685	4.024	1,998	8,333	4.171	7,866,628	31,652,018	4.024

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SUMMARY OF WELLS DRILLED.

The statistics of field operations presented in the following tables are compiled from trade-journal sources and differ somewhat from those on page 985, which are obtained from reports received directly from the oil producers.

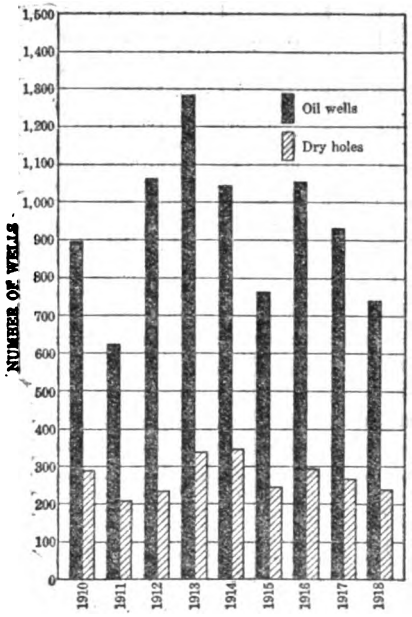

FIGURE 103.—Comparison of number of producing oil wells with dry holes drilled in West Virginia, 1910–1918.

Wells completed in West Virginia, 1914–1918.

County.	Oil.					Dry.					Total completed.[a]				
	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918
Boone	.....	.....	.....	.....	5	.....	.....	.....	.....	1	.....	.....	.....	.....	6
Brooke	15	4	5	1	1	16	10	12	6	7	40	21	22	10	12
Cabell	.....	.....	.....	1	2	.....	.....	.....	.....	2	.....	.....	.....	1	5
Calhoun	5	3	5	23	27	6	1	16	5	3	17	10	26	51	41
Clay	9	14	17	27	9	4	.....	2	2	1	16	17	23	31	10
Gilmer	12	15	.....	8	5	8	10	.....	8	12	23	32	.....	37	32
Hancock	16	5	5	8	3	6	7	6	8	6	23	13	12	18	11
Kanawha	114	86	170	169	102	17	6	8	10	18	153	105	187	210	147
Lincoln	59	88	124	59	26	8	.....	3	2	1	105	96	137	63	28
Marion	311	181	228	210	187	81	33	67	49	61	535	357	533	456	386
Marshall	7	.....	3	4	14	3	2	1	2	2	18	9	7	29	47
Pleasants	74	71	85	78	62	25	24	51	48	32	102	100	139	129	97
Ritchie	125	53	116	98	88	49	49	23	36	30	190	117	160	159	152
Roane	115	64	74	50	73	15	16	5	9	14	152	99	92	63	93
Wetzel and Tyler	81	97	117	78	55	48	50	61	38	27	199	185	305	213	137
Wirt	53	53	63	66	41	24	15	16	21	18	78	72	81	88	59
Wood	47	25	43	53	41	16	15	25	23	5	63	41	68	76	47
Miscellaneous	.....	4	.....	.....	.....	21	8	.....	.....	.....	44	15	1	1	.....
	1,043	763	1,055	933	741	347	246	296	267	240	1,758	1,289	1,793	1,635	1,310

[a] Including gas wells.

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Oil wells and dry holes drilled in West Virginia in 1918.

County.	Jan.		Feb.		Mar.		Apr.		May.		June.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Boone	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Brooke	.....	1	.....	.....	.....	1	1	1	.....	.....	.....	.....
Cabell	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	2	.....
Calhoun	1	.....	1	.....	1	.....	3	.....	.....	2	5	.....
Clay	.....	.....	.....	1	1	.....	1	.....	.....	.....	1	.....
Gilmer	1	3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Hancock	.....	.....	.....	.....	.....	.....	1	.....	.....	1	1	2
Kanawha	7	5	9	.....	7	1	9	1	7	.....	6	2
Lincoln	2	.....	5	.....	2	.....	5	.....	3	.....	1	.....
Marion	9	4	10	5	23	4	10	3	18	7	21	1
Marshall	.....	.....	.....	.....	.....	.....	.....	1	2	.....	1	.....
Pleasants	4	1	2	.....	5	2	11	4	3	5	5	2
Ritchie	2	1	2	.....	7	5	7	6	8	2	6	2
Roane	4	.....	6	1	4	.....	5	.....	6	.....	5	2
Wetzel and Tyler	2	3	2	2	2	2	5	.....	6	1	6	4
Wirt	2	1	.....	.....	5	3	4	2	7	1	5	1
Wood	1	.....	.....	.....	4	.....	4	.....	2	1	4	.....
	35	19	37	9	61	18	66	19	62	20	69	16

County.	July.		Aug.		Sept.		Oct.		Nov.		Dec.		Total.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Boone	.....	.....	5	1	.....	.....	.....	.....	.....	.....	.....	.....	5	1
Brooke	.....	1	.....	2	.....	1	.....	.....	.....	.....	.....	.....	1	7
Cabell	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	2	2
Calhoun	2	.....	5	1	2	.....	3	.....	1	.....	3	.....	27	3
Clay	2	.....	2	.....	.....	.....	1	.....	1	.....	.....	.....	9	1
Gilmer	.....	.....	.....	.....	1	1	.....	2	1	3	2	3	5	12
Hancock	1	.....	.....	.....	.....	2	.....	1	.....	.....	.....	.....	3	6
Kanawha	8	1	10	4	11	1	9	.....	16	1	3	2	102	18
Lincoln	.....	.....	1	.....	2	.....	3	.....	1	.....	1	1	26	1
Marion	17	6	17	4	13	8	16	9	23	6	10	4	187	61
Marshall	2	.....	.....	.....	.....	.....	4	.....	1	.....	4	1	14	2
Pleasants	6	1	7	3	5	3	4	4	2	6	8	1	62	32
Ritchie	12	3	9	4	8	3	9	1	9	1	9	2	88	30
Roane	5	.....	7	1	8	4	8	5	9	1	6	.....	73	14
Wetzel and Tyler	4	4	5	2	10	2	8	3	3	2	2	2	55	27
Wirt	5	2	1	1	3	2	3	.....	1	1	5	4	41	18
Wood	3	4	7	.....	8	.....	5	.....	1	.....	2	.....	41	5
	67	22	76	24	71	27	73	25	69	21	55	20	741	240

Wells completed in West Virginia, 1914–1918.

Month.	Oil.					Dry.					Total completed.[a]				
	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918
January	109	54	66	80	35	31	26	17	18	19	165	102	121	133	69
February	102	55	79	74	37	38	24	11	19	9	174	99	123	142	67
March	95	63	71	78	61	33	27	18	21	18	151	110	121	142	100
April	95	56	78	74	66	37	18	23	17	19	165	98	125	139	108
May	137	76	78	79	62	45	16	27	31	20	202	114	133	135	109
June	101	60	97	101	69	37	22	40	26	16	174	99	181	159	117
July	95	60	98	75	67	29	20	28	29	22	156	110	162	143	121
August	82	65	99	71	76	29	18	24	27	24	154	100	169	127	131
September	48	66	94	72	71	20	17	32	21	27	108	100	172	122	134
October	58	63	111	79	73	11	21	23	17	25	97	111	164	137	132
November	54	73	92	75	69	15	25	31	21	21	104	128	173	132	122
December	67	72	92	75	55	22	12	22	20	29	108	118	149	124	100
	1,043	763	1,055	933	741	347	246	296	267	240	1,758	1,289	1,793	1,635	1,310

[a] Including gas wells.

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Initial daily production of new wells completed in West Virginia in 1918, in barrels.

County.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Boone	.....	.....	.....	.....	.....	.....	.....	73	.....	.....	.....	.....	73
Brooke	.....	.....	.....	5	.....	.....	.....	.....	.....	.....	.....	.....	5
Cabell	.....	.....	.....	.....	.....	8	.....	.....	.....	.....	.....	.....	8
Calhoun	5	5	10	30	.....	38	15	39	8	30	18	41	239
Clay	.....	.....	5	5	.....	10	20	15	.....	10	5	.....	70
Gilmer	15	.....	.....	.....	.....	.....	.....	.....	15	.....	10	16	56
Hancock	.....	.....	.....	3	.....	3	2	.....	.....	.....	.....	.....	8
Kanawha	185	610	155	155	146	255	160	3,050	757	715	2,150	230	8,568
Lincoln	9	28	9	17	15	5	.....	4	4	12	4	10	117
Marion	74	265	505	230	160	257	269	176	162	163	199	163	2,623
Marshall	.....	.....	.....	.....	10	3	3	.....	.....	37	3	89	145
Pleasants	25	3	18	38	21	19	54	28	32	17	3	94	352
Ritchie	45	22	43	64	79	74	84	48	53	54	81	38	685
Roane	35	54	48	37	65	25	34	65	69	70	51	35	588
Wetzel and Tyler	9	20	10	79	56	141	67	66	133	71	39	21	712
Wirt	6	.....	18	15	110	30	9	5	8	14	5	15	235
Wood	5	.....	14	46	14	12	15	31	59	52	5	25	278
	413	1,007	835	724	676	880	732	3,600	1,300	1,245	2,573	777	14,762

Total and average initial daily production of new wells in West Virginia, 1914–1918, by counties, in barrels.

County.	Total initial production.					Average per well.				
	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918
Boone	.....	.....	.....	.....	73	.....	.....	.....	.....	14.6
Brooke	186	17	20	2	5	12.4	4.3	4.0	2.0	5.0
Cabell	.....	.....	.....	1	8	.....	.....	.....	1.0	4.0
Calhoun	22	8	40	258	239	4.4	2.7	8.0	11.0	8.9
Clay	84	261	128	191	70	9.3	18.6	7.5	7.0	7.8
Gilmer	71	109	.....	79	56	5.9	7.3	.....	9.9	11.2
Hancock	105	32	33	37	8	6.6	6.4	6.6	4.9	2.7
Kanawha	8,965	4,724	6,512	6,963	8,568	78.6	54.9	38.3	41.2	84.0
Lincoln	797	821	910	315	117	13.5	9.3	7.3	5.3	4.5
Marion	9,532	3,163	12,163	3,532	2,623	30.6	17.5	53.3	16.8	14.0
Marshall	92	.....	11	23	145	13.1	.....	3.7	5.8	10.4
Pleasants	455	551	694	424	352	6.1	7.8	8.2	5.4	5.7
Ritchie	1,545	536	1,005	1,074	685	12.4	10.1	8.7	11.0	7.8
Roane	931	696	621	482	588	8.1	10.9	8.3	9.6	8.1
Wetzel and Tyler	1,085	2,027	1,242	704	712	13.4	20.9	10.6	9.0	12.9
Wirt	437	410	641	581	235	8.2	7.7	10.2	8.8	5.7
Wood	167	76	214	201	278	3.6	3.0	5.0	3.8	6.8
Miscellaneous	.....	70	.....	.....	.....	.....	17.5	.....	.....	.....
	24,474	13,501	24,234	14,867	14,762	23.5	17.7	23.0	15.9	19.9

Total initial daily production of new wells in West Virginia, 1914–1918, by months, in barrels.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.	Monthly average.
1914	2,178	2,173	2,287	1,741	2,475	2,768	2,263	1,677	1,369	2,850	1,336	1,357	24,474	2,040
1915	1,670	814	1,685	1,112	1,177	753	1,276	981	1,079	699	1,360	895	13,501	1,125
1916	891	833	795	1,502	1,451	2,621	1,965	1,265	1,933	3,678	4,047	3,253	24,234	2,020
1917	1,090	1,441	1,147	1,147	919	1,179	1,451	1,184	1,106	1,665	1,376	1,162	14,867	1,239
1918	413	1,007	835	724	676	880	732	3,600	1,300	1,245	2,573	777	14,762	1,230

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KENTUCKY.

GENERAL STATEMENT.

Kentucky was the center of interest in the eastern fields in 1918, and the results are shown in an increase of 41 per cent in production, of 32 per cent in total number of new wells drilled, of 50 per cent in the number of oil wells completed, and of 60 per cent in the value of output. The year was marked by intensive drilling of pools opened up in the previous years and in the active search for new pools and extensions of the older pools. A total of 2,167 wells was drilled during the year, an increase of 529, compared with 1917. Of these 1,737,or 80.2 per cent, were oil wells credited with an average production of 28 barrels for the first day of productive life, 78 were gas wells, and 352 were dry holes.

Increase in drilling costs and scarcity of labor and of all kinds of material tended to discourage the exploration for new territory, whereas increased prices for crude petroleum encouraged the drilling of new wells, especially in proved areas, and the maximum production of oil from producing wells. The results are shown in a marked decrease in the percentage of dry holes and a slight decrease in the average initial production from new wells.

DEVELOPMENT.

Wells were completed in 40 counties in 1918 and productive oil wells were completed in 31 counties. By far the greatest activity was in Lee County, in the eastern part of the State, where a total of 697 wells was completed, of which 656 were oil wells with an average initial capacity of 47.9 barrels. In 1917, only 58 wells were drilled in this county, of which 43 were oil wells with an average initial production of only 18 barrels. This new drilling marks the development of the Big Sinking pool and other smaller pools. The producing area north and east of Beattyville is a southern extension of the Big Sinking pool. Drilling in this section is a little deeper and the wells a little smaller than in the Big Sinking pool. The larger wells in Big Sinking pool in 1918 did not have an initial production of more than 300 barrels a day each.

Next to Lee County in importance as a producing county was Allen County, in the western central part of the State. Operations in this county did not begin on a large scale until 1918, when 219 wells were drilled, of which 174 were rated as oil wells, whose initial production ranged from 10 to 200 barrels a day each. Allen County is essentially a region of shallow wells relatively easy and cheap to operate. The declining production of individual wells, however, is rapid. An increase in drilling activity compared with 1917 was shown in the following counties: Allen, Barren, Estill, Floyd, Lee, Lincoln, Magoffin, Morgan, Ohio, Pulaski, Simpson, Warren, and Wolfe. The following were added to the list of producing counties: Breathitt, Elliott, Hopkins, Johnson, Knott, Menifee, Owsley, and Union.

The new production in Kentucky was taken care of by the Cumberland Pipe Line, which made extensions to the new pools in Estill, Lee, Powell, and Wolfe counties. In addition the National Refining Co. furnished a line from the Big Sinking field in Lee County to Beattyville to handle its production from the Flathaven tract. Two or three

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other companies have also put in short lines to handle their own production.

In the western division of the State the most active county was Allen, of which Scottsville is the center. During the year the Indian Refining Co. installed a line from the famous Johnson pool in the north end of Allen County to a loading station at Scottsville, and after finishing that line extended other field lines to take in some of the additional production scattered over Allen County. A few of the producing companies have also installed lines and are shipping crude to outside refineries. Another line that was put in during 1918 was that of the American Pipeline Co., which runs from the Johnson pool through Warren County to its terminus at Bowling Green. Another line is that of the Daniel Boone Oil Co., which was built into Lincoln County and from the field in that county to Waynesburg, where the oil is loaded on tank cars and shipped by train to a refinery at Louisville.

PETROLEUM PRODUCED.

Petroleum produced in Kentucky, 1914–1918, in barrels.

Month.	1914	1915	1916	1917	1918
January	46,930	34,898	33,751	154,378	265,223
February	44,545	35,707	40,657	139,417	287,524
March	53,860	39,562	51,323	174,299	322,479
April	50,465	40,015	65,545	165,331	312,322
May	44,903	39,323	85,638	240,024	316,164
June	44,361	37,070	81,409	266,328	305,571
July	42,630	35,905	94,001	318,776	355,899
August	26,758	37,531	134,219	320,529	383,467
September	21,177	34,929	143,093	230,626	415,451
October	51,625	33,564	162,060	352,481	448,363
November	36,900	34,702	157,685	339,783	459,876
December	38,287	34,068	153,188	286,188	495,629
	502,441	437,274	1,202,569	3,088,160	4,367,968

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Pipe-line runs in Kentucky in 1917 and 1918, in barrels.

1917.

Month ending—	Wayne County.					Wolfe County.				Estill County.			
	Cooper.	Griffin (Denny).	Parmleysville.	Steubenville.	Total.	Campton.	Stillwater.	Page Hollow.	Total.	Ravenna Irvine.	Fitchburg.	Wagersville.	Total.
Feb. 3	4,191	3,721	3,776	3,884	15,572	2,279	1,324	.....	3,603	106,049	22,530	5,375	133,954
Mar. 3	3,966	3,062	2,544	3,221	12,793	1,122	760	.....	1,882	71,398	18,481	16,600	106,479
Mar. 31	3,709	2,958	2,913	2,964	12,544	973	1,321	.....	2,294	84,797	28,898	26,457	140,152
Apr. 28	4,003	3,355	3,114	3,116	13,588	1,781	1,865	.....	3,646	56,491	21,901	34,733	113,125
June 2	4,433	3,543	3,272	3,876	15,124	1,180	2,707	902	4,789	130,496	45,093	38,459	214,048
June 30	3,886	3,137	3,768	3,095	13,886	1,831	3,136	687	5,654	106,290	66,750	20,976	194,016
July 28	3,988	2,708	2,827	5,588	15,111	2,422	2,484	.....	4,906	119,445	79,890	19,029	218,364
Sept. 1	5,140	2,571	3,395	3,818	14,924	2,636	1,812	.....	4,448	128,967	95,937	12,230	237,134
Sept. 29	3,840	2,571	2,463	2,797	11,671	1,220	862	.....	2,082	115,094	82,664	10,146	207,904
Nov. 3	5,972	3,256	2,844	3,752	15,824	2,985	1,097	.....	4,082	123,842	103,650	11,823	238,820
Dec. 1	3,658	2,798	2,612	3,624	12,692	1,256	1,439	.....	2,695	96,547	84,661	9,250	190,458
Dec. 29	2,540	2,382	1,785	3,252	9,959	1,407	1,156	.....	2,563	88,183	69,186	6,071	163,440
	49,326	36,062	35,313	42,987	163,688	21,092	19,963	1,589	42,644	1,227,599	719,641	210,654	2,157,894

Month ending—	Lawrence County.			Morgan County.			Beaver Creek.	Ragland.	Williamsburg.	Pilot-Ashley.	Zachariah.	State total.
	Busseyville.	Falisburg.	Total.	Cannel City.	Lewis.	Total.						
Feb. 3	3,809	.....	3,809	.....	2,194	2,194	850	2,319	146	.....	.....	162,447
Mar. 3	3,919	.....	3,919	.....	1,097	1,097	597	2,346	.....	3,740	.....	132,853
Mar. 31	3,749	.....	3,749	.....	1,156	1,156	954	2,734	.....	8,928	.....	172,511
Apr. 28	4,160	.....	4,160	.....	432	432	863	2,524	.....	1,130	.....	139,466
June 2	3,900	.....	3,900	.....	2,658	2,658	688	2,423	.....	17,203	.....	260,833
June 30	4,202	341	4,543	868	589	1,457	748	2,581	.....	17,165	.....	240,050
July 28	843	4,115	4,958	1,281	.....	1,281	571	1,848	.....	31,945	.....	278,984
Sept. 1	1,807	4,769	6,576	1,767	.....	1,767	638	1,721	150	62,324	.....	329,682
Sept. 29	1,017	3,635	4,652	1,228	.....	1,228	1,627	1,373	5,204	73,260	.....	309,001
Nov. 3	1,640	3,855	5,495	1,257	.....	1,257	610	2,883	.....	113,700	318	382,989
Dec. 1	1,139	5,425	6,564	1,377	.....	1,377	542	1,501	.....	90,945	647	307,421
Dec. 29	1,336	2,958	4,294	943	.....	943	529	1,888	.....	74,580	2,476	260,672
	31,521	25,098	56,619	8,721	8,126	16,847	9,217	26,141	5,500	494,920	3,441	2,976,911

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Month ending—	Wayne County.					Wolfe County.			Estill County.			
	Cooper.	Griffin (Denny).	Parmleysville.	Steubenville.	Total.	Campton.	Stillwater.	Total.	Ravenna Irvine.	Fitchburg.	Wagersville.	Total.
Feb. 2	3,436	2,198	2,390	3,599	11,623	2,043	1,092	3,135	97,103	69,971	5,460	172,534
Mar. 2	3,355	3,772	2,808	4,015	13,950	964	2,003	2,967	98,613	76,381	5,939	180,933
Mar. 30	3,061	2,780	2,145	5,119	13,105	1,030	1,228	2,258	104,244	71,038	5,131	180,413
Apr. 27	3,593	3,051	2,235	4,215	13,094	533	1,411	1,944	98,408	64,210	3,491	166,109
June 1	5,004	3,113	2,904	6,095	17,116	1,712	1,869	3,581	105,223	69,111	4,041	178,375
June 29	3,173	2,403	2,620	4,191	12,387	969	1,464	2,433	75,259	57,079	2,863	135,201
Aug. 3	5,320	3,137	3,093	5,165	16,715	2,061	1,852	3,913	84,933	62,870	2,968	150,771
Aug. 31	4,100	1,972	2,128	3,762	11,962	2,145	1,423	3,568	64,568	45,521	2,086	112,175
Sept. 30	3,735	2,296	3,002	3,498	12,531	721	1,429	2,150	59,044	48,306	1,641	108,991
Nov. 2	4,439	2,857	3,516	4,389	15,201	1,268	770	2,038	66,546	53,146	1,962	121,654
Nov. 30	2,977	1,481	3,455	3,273	11,186	1,466	1,111	2,577	44,496	38,327	1,631	84,454
Dec. 28	3,429	2,193	2,681	2,871	11,174	933	423	1,356	44,899	34,935	1,121	80,955
	45,622	31,253	32,977	50,192	160,044	15,845	16,075	31,920	943,336	690,895	38,334	1,672,565

Month ending—	Lawrence County.			Lee County.				Pilot.	Beaver Creek.	Cannel City.	Ragland.	Williamsburg.	Olympic.	Salt Lick.	State total.
	Busseyville.	Fallsburg.	Total.	Ross Creek.	Big Sinking.	Zacharish.	Total.								
Feb. 2	1,814	4,261	6,075	.....	.....	5,306	5,306	90,867	600	1,777	1,454	152	.....	.....	293,523
Mar. 2	2,351	3,903	6,254	.....	.....	4,259	4,259	70,071	680	1,193	1,760	.....	.....	.....	282,067
Mar. 30	1,703	3,706	5,409	.....	.....	7,691	7,691	70,556	458	1,356	2,434	302	.....	.....	283,982
Apr. 27	1,638	3,678	5,316	.....	.....	10,866	10,866	86,067	893	1,342	1,934	.....	.....	.....	287,565
June 1	1,261	6,135	7,396	.....	.....	29,522	29,522	94,025	1,037	2,173	2,161	.....	.....	.....	335,386
June 29	1,396	3,633	5,029	.....	.....	31,698	31,698	70,718	938	1,977	1,035	.....	.....	.....	261,416
Aug. 3	1,928	4,330	6,258	1,911	20,140	47,820	69,880	90,613	1,503	2,103	2,007	449	.....	.....	344,212
Aug. 31	1,512	2,449	3,961	16,013	102,870	18,422	137,305	59,331	1,089	1,260	1,679	300	.....	.....	332,580
Sept. 30	951	3,241	4,192	26,111	126,978	15,577	168,666	61,094	1,271	1,301	2,160	150	.....	.....	362,506
Nov. 2	2,370	3,586	5,956	42,120	174,976	20,059	237,155	69,300	2,033	1,578	1,530	.....	108	.....	456,553
Nov. 30	1,198	3,483	4,681	38,398	162,476	16,629	217,503	49,042	1,291	1,353	1,148	.....	.....	360	373,595
Dec. 28	1,110	3,396	4,506	37,792	176,842	14,082	228,716	48,389	1,395	1,350	1,966	.....	.....	.....	379,807
	19,232	45,801	65,033	162,345	764,282	221,940	1,148,567	860,073	13,138	18,763	21,268	1,353	108	360	3,993,192

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SUMMARY OF WELLS DRILLED.

The statistics of field operations presented in the following tables are compiled from trade-journal sources and differ somewhat from those on page 986, which are obtained from reports received directly from the oil producers.

Wells completed in Kentucky, 1914–1918.

County.	Oil.					Dry.					Total completed.[a]				
	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918
Adair				2	2				2					4	2
Allen	16	1	99	88	174	1	1	28	65	37	19	2	131	153	219
Barren			5	5	44			1	2				6	10	46
Bath			1	15	2			1	7	7			3	25	9
Boyle				1					2					3	
Breathitt					10				1	4				1	19
Daviess	2					1	3				3	3			
Edmonson		1								1		1			1
Elliott					3					5					10
Estill	3	2	681	604	369			86	142	47	3	2	773	749	418
Floyd				2	2	1		2			1		2	3	4
Grayson				2	3				3	2			1	6	6
Hopkins					3				1					1	3
Jackson				9	9			3	11	2			3	20	13
Johnson	1				8				2	5	1			3	24
Knott					1										1
Knox				20	20				5	6				35	26
Lawrence	9	10	20	27	21		2	1	5	6	10	12	21	34	27
Lee			2	43	656			2	13	39			4	58	697
Lincoln				16	37				6	12				30	59
McCreary				8					2	2				10	2
Madison			1						2	1			3	2	1
Magoffin				5	6									5	13
Martin			1										1		
Menifee					4					1				1	5
Metcalfe			2	4	2			2	5	3			4	9	5
Monroe				1					1					2	
Morgan	10	1	2	5	9	5	1	5	4	3	15	2	7	12	25
Ohio	4				1	4					8				1
Owsley					7				2	5				2	12
Powell			21	227	227			10	58	57			32	286	286
Pulaski				1	8				3	2				6	14
Rockcastle				12	1			7	3	5			8	15	6
Simpson				2	2				1	2			1	3	4
Union					1										1
Warren			1	6	9				5	14			2	11	24
Wayne	68	31	29	22	29	34	27	27	28	15	102	58	56	50	45
Whitley			1	4				1	5	3			2	13	3
Wolfe	6	10	12	22	67	4	1	1	15	24	10	11	13	37	91
Miscellaneous						5	1	2	16	37	6	1	2	38	45
	119	56	378	1,162	1,737	55	36	179	417	352	178	92	1,074	1,638	2,167

[a] Including gas wells.

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Oil wells and dry holes drilled in Kentucky in 1918.

County.	Jan.		Feb.		Mar.		Apr.		May.		June.		July.		Aug.		Sept.		Oct.		Nov.		Dec.		Total.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Adair															2										2	
Allen	5	3	9		11	4	14	6	9	1	10		11	2	20	3	12	3	33	5	16	3	24	7	174	37
Barren	2		2		1		5				6		7		4		2		7		5		3		44	
Bath				1						1						2	1					1	1	2	2	7
Breathitt			1				4	1							2	1	1	1	1		1	1			10	4
Edmonson										1																1
Elliott									1	2	1					1	1			1		1			3	5
Estill	11	2	10	3	28	1	32	4	39	5	25	6	42	5	38	6	40	5	33	2	33	5	38	3	369	47
Floyd							1										1								2	
Grayson					1					1					1			1	1					3	2
Hopkins																	3								3	
Jackson													2		6		1			1		1			9	2
Johnson	2									1			2										4	4	8	5
Knott																	1								1	
Knox	2		1					1	1	3	2	1	7								4	1	3		20	6
Lawrence	3	2			2	3	1	1			1		4	1	1		3		1		3		1		21	6
Lee	5		19	1	21	3	30	4	38	3	53	6	97	8	77	5	86	1	61	2	58	4	111	2	656	39
Lincoln					1		10		5	1	2				2		2		13	11	2				37	12
McCreary																				1		1				2
Madison				1																						1
Magoffin	1		2										2				1								6	
Menifee											1				1		1						1	1	4	1
Metcalfe									1												1	1		2	2	3
Morgan		1	3	1	1		1		1		1	1	1	2				1		1	1	1			9	8
Ohio													1												1	
Owsley					2	1	1		1		1	1		1					1	1			1	1	7	5
Powell	17	4	20	3	42	10	34	7	34	5	16	2	24	8	10	3	10	5	6	3	5	5	9	2	227	57
Pulaski					1							1	3				2	1			2				8	2
Rockcastle			1					1						2								2			1	5
Simpson											1	1			1							1			2	2
Union									1																1	
Warren		2	1	2		1			1		1	1			2	1	2	2	1	3	1	1		1	9	14
Wayne	2		1	2	3		3	2	3	1	1	2	1	3		2	2	2	5		2		6	1	29	15
Whitley				1										1				1								3
Wolfe	4	3	5	3	2	5	8		4	1	8	3	5		7	2	7	1	2	6	1		14		67	24
Miscellaneous				5		7		1		1		1		5		4		6		1		5		1		37
	54	17	75	23	114	34	146	28	140	27	130	26	209	38	174	30	179	30	165	38	135	34	216	27	1,737	352

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Wells completed in Kentucky, 1914–1918.

Month.	Oil.					Dry.					Total completed.[a]				
	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918
January	11	1	48	76	54	5	3	7	22	17	16	4	58	100	77
February	12	3	25	78	75	7	4	7	23	23	19	7	32	105	102
March	11	4	30	83	114	2	1	8	27	34	13	5	38	113	153
April	14	5	35	81	146	7	.....	6	23	28	21	5	41	108	176
May	8	10	51	123	140	4	9	15	37	27	12	19	66	161	171
June	14	5	48	106	130	8	6	3	53	26	22	11	52	162	161
July	12	4	104	77	209	5	2	15	43	38	18	6	120	123	249
August	14	3	94	104	174	6	1	25	50	30	20	4	122	163	208
September	8	2	121	104	179	5	1	31	23	30	14	3	156	133	220
October	3	5	123	135	165	3	3	30	30	38	7	8	153	173	217
November	8	6	96	106	135	2	4	12	41	34	10	10	110	155	174
December	4	8	103	89	216	1	2	20	45	27	6	10	126	142	259
	119	56	878	1,162	1,737	55	36	179	417	352	178	92	1,074	1,638	2,167

[a] Including gas wells.

Initial daily production of new wells completed in Kentucky in 1918, in barrels.

County.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Adair	.....	.....	.....	.....	.....	.....	.....	10	.....	.....	.....	.....	10
Allen	75	250	147	240	176	178	475	750	855	715	1,303	1,080	6,244
Barren	25	30	10	25	.....	60	70	100	15	95	150	30	610
Bath	.....	.....	.....	.....	.....	.....	.....	.....	5	.....	.....	1	6
Breathitt	.....	5	.....	15	.....	.....	.....	40	5	25	100	.....	190
Elliott	.....	.....	.....	.....	5	10	.....	.....	5	.....	.....	.....	20
Estill	120	110	248	427	325	238	409	287	677	509	475	418	4,243
Floyd	.....	.....	.....	5	.....	.....	.....	.....	5	.....	.....	.....	10
Grayson	.....	.....	25	.....	.....	.....	.....	15	.....	25	.....	.....	65
Hopkins	.....	.....	.....	.....	.....	.....	.....	.....	6	.....	.....	.....	6
Jackson	.....	.....	.....	.....	.....	.....	30	75	10	.....	.....	.....	115
Johnson	20	.....	.....	.....	.....	.....	10	.....	.....	.....	.....	33	63
Knott	.....	.....	.....	.....	.....	.....	.....	.....	10	.....	.....	.....	10
Knox	10	5	.....	.....	5	10	40	.....	.....	.....	14	15	99
Lawrence	11	.....	.....	14	4	2	21	10	19	5	17	2	105
Lee	105	645	437	755	1,090	1,675	3,095	3,238	4,100	3,920	4,162	8,170	31,392
Lincoln	.....	.....	20	50	25	10	.....	20	20	121	40	.....	306
Magoffin	10	5	.....	.....	.....	.....	10	.....	5	.....	.....	.....	30
Menifee	.....	.....	.....	.....	.....	5	.....	5	20	.....	.....	35	65
Metcalfe	.....	.....	.....	.....	5	.....	.....	.....	.....	.....	5	.....	10
Morgan	.....	45	5	10	5	10	5	.....	.....	.....	20	.....	100
Ohio	.....	.....	.....	.....	.....	.....	5	.....	.....	.....	.....	.....	5
Owsley	.....	.....	6	5	10	15	.....	.....	.....	20	.....	20	76
Powell	217	750	705	455	306	190	202	87	67	123	55	142	3,299
Pulaski	.....	.....	5	.....	.....	.....	20	.....	10	.....	10	.....	45
Rockcastle	.....	10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	10
Simpson	.....	.....	.....	.....	.....	5	.....	5	.....	.....	.....	.....	10
Union	.....	.....	.....	.....	10	.....	.....	.....	.....	.....	.....	.....	10
Warren	.....	10	.....	.....	5	5	.....	25	23	5	10	.....	83
Wayne	10	10	11	45	10	5	10	.....	12	55	10	18	196
Wolfe	115	55	75	96	50	135	27	135	168	75	20	237	1,188
	718	1,930	1,604	2,142	2,031	2,553	4,429	4,802	6,037	5,693	6,391	10,201	48,621

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Total and average initial daily production of new wells in Kentucky, 1914–1918, by counties, in barrels.

County.	Total initial production.					Average per well.				
	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918
Adair				8	10				4.0	5.0
Allen	335	50	3,877	3,713	6,244	20.9	50.0	39.2	42.1	35.9
Barren			22	61	610			4.4	12.2	13.9
Bath			30	276	6			30.0	18.4	3.0
Boyle				4					4.0	
Breathitt					190					19.0
Daviess	10					5.0				
Edmonson		10					10.0			
Elliott					20					6.7
Estill	23	125	22,581	19,216	4,243	7.7	62.5	33.2	31.8	11.5
Floyd				6	10				3.0	5.0
Grayson				10	65				5.0	21.7
Hopkins					6					2.0
Jackson				145	115				16.1	12.8
Johnson	10				63	10.0				7.9
Knott					10					10.0
Knox				375	99				12.9	5.0
Lawrence	69	78	94	183	105	7.7	7.8	4.7	6.8	5.0
Lee			35	774	31,392			17.5	18.0	47.9
Lincoln				104	306				6.5	8.3
McCreary				137					17.1	
Madison			5					5.0		
Magoffin				26	30				5.2	5.0
Martin			10					10.0		
Menifee					65					16.3
Metcalfe			12	25	10			6.0	6.3	5.0
Monroe				5					5.0	
Morgan	96	3	30	46	100	9.6	3.0	15.0	9.2	11.1
Ohio	150				5	37.5				5.0
Owsley					76					10.8
Powell			365	9,430	3,299			17.4	41.5	14.5
Pulaski				10	45				10.0	5.6
Rockcastle				34	10				2.8	10.0
Simpson				15	10				7.5	5.0
Union					10					10.0
Warren			1	120	83			1.0	20.0	9.2
Wayne	843	408	106	117	196	12.4	13.2	3.7	5.3	6.8
Whitley			10	175				10.0	43.8	
Wolfe	32	54	132	278	1,188	5.3	5.4	11.0	12.6	17.7
	1,568	728	27,310	35,293	48,621	13.2	13.0	31.1	30.4	28.0

Total initial daily production of new wells in Kentucky, 1914–1918, by months, in barrels.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.	Monthly average.
1914	140	238	148	267	94	122	155	165	120	28	66	25	1,568	131
1915	1	122	33	119	128	24	14	25	6	53	30	173	728	61
1916	660	517	779	1,281	1,123	2,114	3,678	3,659	3,412	3,331	3,227	3,529	27,310	2,276
1917	3,018	4,596	4,259	3,973	5,651	1,586	1,536	1,897	2,565	2,710	1,961	1,541	35,293	2,941
1918	718	1,930	1,694	2,142	2,031	2,553	4,429	4,802	6,037	5,693	6,391	10,201	48,621	4,052

TENNESSEE.

GENERAL STATEMENT.

In 1918 Tennessee was credited with a production of 8,374 barrels of petroleum. This marks a decrease of 3,822 barrels from the production in 1917 but an increase of 7,697 barrels over the production in 1916. During the year 1918, 23 wells are reported to have been completed, of which 14 were oil wells, 3 were gas wells, and 6 were dry holes. Ten of the 14 oil wells were drilled in Scott County, the average reported initial daily yield of which was 24 barrels. The remaining 4 oil wells were sunk in Pickett County.

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PETROLEUM PRODUCED.

Petroleum produced in Tennessee, 1916–1918, in barrels.

Month.	1916	1917	1918
January			993
February		797	927
March		1,127	617
April			773
May	464	1,138	486
June		380	776
July		274	468
August	213	927	689
September		2,960	457
October		1,650	1,678
November		1,307	767
December		536	464
	677	12,196	8,376

SUMMARY OF WELLS DRILLED.

Wells completed in Tennessee in 1916–1918.

County.	Oil.			Dry.			Total completed.a		
	1916	1917	1918	1916	1917	1918	1916	1917	1918
Fentress				1			1		
Macon						1			1
Morgan						1			1
Pickett			4						4
Scott	2	8	10	6		1	8	11	12
Smith						1			1
Sumner						2			4
	2	8	14	7		6	9	11	23

aIncluding gas wells.

Oil wells and dry holes drilled in Tennessee in 1918.

County.	Jan.		Feb.		Mar.		Apr.		May.		June.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Macon				1								
Morgan												
Pickett											1	
Scott				1			3					
Smith												
Sumner												
				2			3				1	

County.	July.		Aug.		Sept.		Oct.		Nov.		Dec.		Total.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Macon														1
Morgan											1			1
Pickett					1		1		1				4	
Scott					7								10	1
Smith											1			1
Sumner						2								2
					8	2	1		1		2		14	6

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Wells completed in Tennessee in 1916–1918.

Month.	Oil.			Dry.			Total completed.[a]		
	1916	1917	1918	1916	1917	1918	1916	1917	1918
January	2						2		
February		1				2		1	2
March		1						1	
April			3					1	4
May									
June		3	1					3	1
July	5						5		
August									
September		3	8	1		2	1	3	12
October			1					1	1
November			1	1		2	1		3
December								1	
	7	8	14	2		6	9	11	23

[a] Including gas wells.

Initial daily production of new wells completed in Tennessee in 1918, in barrels,

County.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Pickett						3			5	5	5		18
Scott				90					150				240
				90		3			155	5	5		258

Total and average initial daily production of new wells in Tennessee in 1916–1918, in barrels.

County.	Total initial production.			Average per well.		
	1916	1917	1918	1916	1917	1918
Pickett			18			4.5
Scott	45	615	240	22.5	76.9	24.0
	45	615	258	22.5	76.9	18.4

Total initial daily production of new wells in Tennessee in 1916–1918, by months, in barrels.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec..	Total.	Monthly average.
1916									25		20		45	4
1917		250	200			70			95				615	51
1918				90		3			155	5	5		258	22

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OHIO.[1]

GENERAL STATEMENT.

Ohio as a whole failed to respond to the increased demand for petroleum in 1918. The decrease took place, however, in the old Lima field in the northwestern part of the State, the central and southeastern parts showing a slight increase. The production of the entire State in 1918 was 7,285,005 barrels, a decrease of 465,535 barrels, or 6 per cent, compared with 1917. The southeastern and central division belonging to the Appalachian field contributed 4,941,841 barrels, or 67.8 per cent, in 1918, as compared with 4,839,679 barrels in 1917. The total value of the oil produced in this territory in 1918 was $18,042,394, an increase of $2,569,689 over the value in 1917, and the average price was $3.65 per barrel, as compared with $3.20 in 1917. The northwestern division, comprising the old Lima field—a part of the Lima-Indiana field—contributed 2,343,164 barrels, or 32.2 per cent, a decrease of 567,697 barrels, or 19.5 per cent, from the output in 1917, a decrease due largely to diminished activity in drilling.

DEVELOPMENT.

SOUTHEASTERN AND CENTRAL OHIO.

A total of 1,695 wells was completed in southeastern and central Ohio in 1918, as compared with 1,828 in 1917. Of the wells drilled in 1918, 803, or 47.4 per cent, were oil wells with an average initial production of 15 barrels, 446 were gas wells, and 446 were dry holes. The percentage of dry holes was slightly less than in 1917. The statistics showed a marked decrease in the number of new wells in Washington County, in the Marietta and Macksburg pools, and in Jefferson and Columbiana counties. Other counties in the "shallow sand" area—Carroll, Harrison, Noble, Morgan, Belmont, Monroe, and Athens—showed increase in the number of producing wells. In the Clinton sand areas, Coshocton, Holmes, Medina, and Wayne counties showed increase in the number of new oil wells, whereas Hocking, Knox, Licking, Fairfield, Perry, and Muskingum showed decrease.

NORTHWESTERN OHIO (LIMA FIELD).

In all 416 new wells were completed in 1918, compared with 534 in 1917. Of these, 369 produced an average of 15 barrels of oil each on the first day of productive life, 9 were gas wells, and 38, or 9 per cent were dry holes. It is notable that the percentage of dry holes in this field is comparatively low and has remained fairly constant for the last 10 years at an average of a little less than 10 per cent.

Field activity in the oil districts of northwestern Ohio was confined generally to the drilling of wells in territory from which the flush production was obtained years ago and to the intensive development of restricted pools overlooked in the course of the earlier development work of the region. This type of development work

[1] Of the two areas of oil production in Ohio only the southeastern-central area belongs geographically in the Appalachian oil field, the Lima area, in northwestern Ohio, forming a part of the so-called Lima-Indiana oil field. In accordance with the custom in previous reports, however, the statistics for both areas are given here, to make the statement for Ohio cover the whole State. The Lima statistics are, of course, omitted from the tables covering the Appalachian field as a whole.

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resulted in seven wells in Seneca County, and three in Wood County having initial production of 100 barrels or more.

A total of 770 wells are reported as abandoned during the year, a decrease in the number of producing wells of 401. Compared with this, 1,245 wells were abandoned in 1917, a decrease in the number of producing wells in that year of 772.

PETROLEUM PRODUCED.

Petroleum produced in Ohio in 1914-1918, in barrels.

Month.	Lima.				
	1914	1915	1916	1917	1918
January	341,162	271,437	247,491	260,916	120,207
February	223,310	274,450	252,535	208,869	164,884
March	343,414	311,095	287,652	273,073	217,328
April	338,745	313,775	271,492	250,248	214,746
May	329,256	283,022	287,382	270,702	231,163
June	331,060	295,378	277,206	266,356	207,362
July	337,431	291,978	265,272	252,166	217,391
August	319,529	275,442	269,449	253,704	211,306
September	312,202	276,998	250,038	223,100	187,005
October	314,526	278,632	260,332	244,957	206,196
November	275,469	261,197	248,223	231,764	175,802
December	254,983	260,429	218,895	185,006	189,774
	3,727,087	3,393,833	3,135,967	2,910,861	2,343,164

Month.	Southeastern and central Ohio.				
	1914	1915	1916	1917	1918
January	444,426	382,236	355,553	389,402	324,683
February	363,537	361,100	344,767	352,102	366,058
March	464,675	398,430	385,306	415,850	434,727
April	448,909	385,427	371,192	398,347	424,969
May	436,266	362,097	401,866	430,389	447,544
June	428,753	377,345	423,673	412,722	404,764
July	456,139	366,426	389,532	424,766	446,774
August	195,617	357,799	409,467	434,381	426,177
September	299,372	353,556	376,239	394,632	397,027
October	507,031	363,534	388,561	429,751	445,492
November	373,117	342,700	386,229	401,629	396,973
December	391,423	380,843	377,159	355,708	426,653
	4,809,265	4,431,493	4,608,544	4,839,679	4,941,841

Month.	Total.				
	1914	1915	1916	1917	1918
January	785,588	653,673	603,044	640,318	444,890
February	592,847	635,550	597,302	560,971	530,942
March	808,089	709,525	672,958	688,923	652,055
April	787,654	699,202	642,684	648,595	639,715
May	765,522	645,119	689,248	701,091	678,707
June	759,813	672,723	699,879	679,078	612,126
July	793,570	658,404	654,804	676,932	664,165
August	515,146	633,241	678,916	688,085	637,483
September	611,574	630,554	626,277	617,732	584,032
October	821,557	642,166	648,893	674,708	651,688
November	648,586	603,897	634,452	633,393	572,775
December	646,406	641,272	596,054	540,714	616,427
	8,536,352	7,825,326	7,744,511	7,750,540	7,285,006

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Quantity, value, and average price per barrel of petroleum produced in Ohio, 1909–1918.

Year.	Lima.			Southeastern and central Ohio.			Total.		
	Quantity (barrels).	Value.	Average price per barrel.	Quantity (barrels).	Value.	Average price per barrel.	Quantity (barrels).	Value.	Average price per barrel.
1909....	5,915,357	$5,451,497	$0.921	4,717,426	$7,773,880	$1.647	10,632,793	$13,225,377	$1.243
1910....	5,094,136	4,181,629	.821	4,822,234	6,469,939	1.341	9,916,370	10,651,568	1.074
1911....	4,535,875	3,888,119	.857	4,281,237	5,591,423	1.306	8,817,112	9,479,542	1.075
1912.... [a]	3,955,897	3,908,809	.988	5,013,110	8,177,189	1.628	8,969,007	12,085,998	1.347
1913....	3,817,043	5,308,842	1.391	4,964,425	12,229,610	2.463	8,781,468	17,538,452	1.997
1914....	3,727,087	4,435,314	1.190	4,809,365	8,937,415	1.858	8,536,352	13,372,729	1.567
1915....	3,398,838	3,300,833	.973	4,431,498	6,760,660	1.526	7,825,336	10,061,493	1.286
1916....	3,135,967	4,909,704	1.566	4,608,544	11,245,236	2.440	7,744,511	16,154,940	2.086
1917....	2,910,861	5,631,778	1.935	4,839,679	15,472,705	3.197	7,750,540	21,104,483	2.723
1918....	2,343,164	5,422,803	2.314	4,941,841	18,042,394	3.651	7,285,005	23,465,197	3.221

[a] Includes production of Michigan.

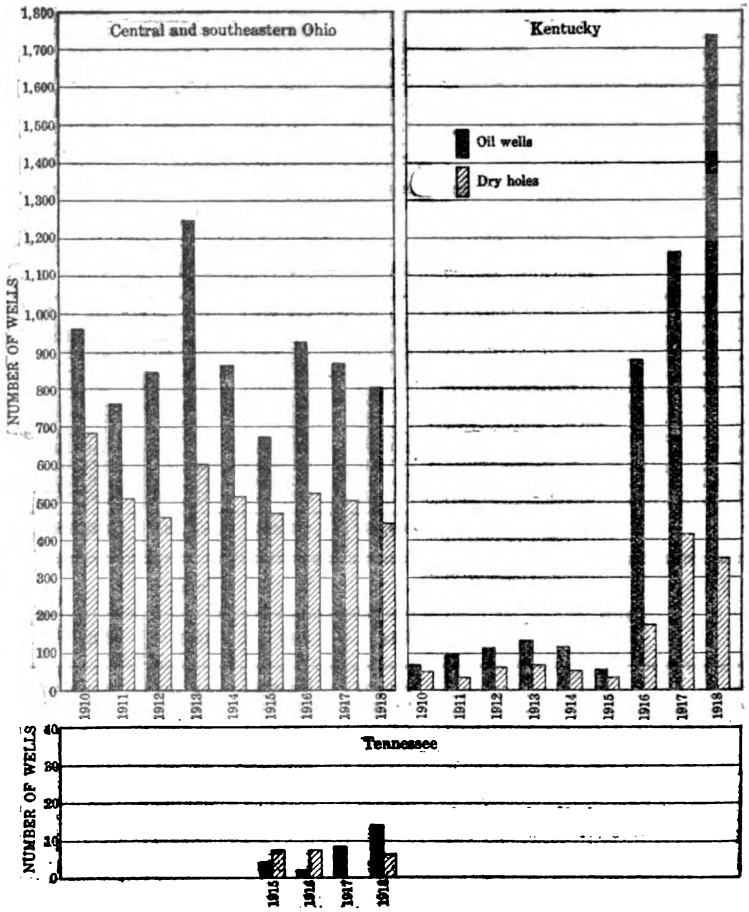

FIGURE 104.—Comparison of number of producing oil wells with dry holes drilled in central and southeastern Ohio, Kentucky, and Tennessee, 1910–1918.

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SUMMARY OF WELLS DRILLED.

The statistics of field operations presented in the following tables are compiled from trade-journal sources and differ somewhat from those on pages 986–987, which are obtained from reports received directly from the oil producers.

SOUTHEASTERN AND CENTRAL DIVISION.

Wells completed in southeastern and central Ohio, 1914–1918.

County.	Oil.					Dry.					Total completed.a				
	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918
Ashland	2	1	1	.....	1	15	27	22	30	14	88	88	57	73	35
Ashtabula	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	1	.....	.....
Athens	7	16	16	31	37	7	4	4	10	21	19	21	21	42	60
Belmont	15	12	14	9	13	24	13	9	12	5	55	34	29	34	26
Carroll	29	24	19	40	41	7	13	9	16	8	38	41	29	61	52
Columbiana	58	37	16	19	5	12	23	18	17	6	72	64	46	39	11
Coshocton	13	2	4	12	48	5	4	3	7	4	18	7	8	24	59
Cuyahoga	7	13	19	5	.....	35	68	29	11	18	384	515	169	58	74
Erie	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	2	.....	.....	.....	.....
Fairfield	25	12	13	5	4	13	7	9	6	9	44	23	30	22	19
Guernsey	.....	.....	.....	.....	.....	2	.....	.....	.....	.....	2	.....	.....	.....	.....
Harrison	17	12	13	12	19	7	2	9	7	19	25	16	25	22	43
Hocking	97	71	95	71	58	48	17	27	32	29	181	105	127	122	105
Holmes	.....	.....	6	3	17	.....	3	3	3	7	.....	3	10	13	44
Jackson	.....	.....	.....	.....	.....	.....	.....	1	5	2	.....	.....	1	9	7
Jefferson	33	16	30	41	22	16	14	22	22	6	58	32	67	63	28
Knox	.....	1	5	11	1	1	5	.....	16	4	1	13	9	31	17
Licking	16	16	18	12	6	18	9	13	12	9	92	68	74	53	24
Lorain	.....	.....	.....	.....	.....	3	3	2	1	3	4	5	5	7	7
Marion	.....	.....	.....	1	.....	.....	.....	.....	1	1	.....	.....	.....	2	1
Medina	.....	4	3	6	23	7	11	8	15	22	29	28	24	73	103
Meigs	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	1	.....	.....
Monroe	51	34	60	33	45	35	17	17	14	15	98	53	82	50	63
Morgan	91	64	35	56	80	45	21	20	18	35	136	85	56	74	118
Muskingum	15	19	71	79	54	5	7	18	9	8	28	27	92	98	68
Noble	45	36	22	42	57	40	25	31	22	28	96	67	57	64	89
Perry	112	41	104	102	92	34	12	18	23	30	151	55	123	141	157
Richland	.....	.....	.....	.....	.....	16	10	2	5	5	36	32	11	23	26
Tuscarawas	.....	.....	2	2	.....	.....	.....	2	4	.....	.....	.....	4	9	.....
Vinton	.....	6	25	4	4	2	14	29	21	13	6	41	170	96	79
Washington	221	240	326	253	150	104	111	183	141	89	338	360	525	405	252
Wayne	9	.....	1	19	26	15	31	16	24	35	61	126	62	125	131
	863	677	927	868	803	517	472	525	504	446	2,044	1,910	1,854	1,828	1,696

a Including gas wells.

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Oil wells and dry holes drilled in southeastern and central Ohio, in 1918.

State.	Jan.		Feb.		Mar.		Apr.		May.		June.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Ashland	.....	2	.....	1	.....	.....	.....	1	.....	.....	.....	3
Athens	.....	.....	2	3	.....	2	7	1	2	2	.....	.....
Belmont	1	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....
Carroll	1	.....	2	1	3	1	3	.....	4	1	5	.....
Columbiana	2	.....	.....	.....	.....	.....	.....	2	1	1	.....	.....
Coshocton	.....	.....	1	.....	.....	.....	3	.....	4	1	7	.....
Cuyahoga	.....	1	.....	1	.....	3	.....	2	.....	3	.....	3
Fairfield	.....	.....	.....	.....	1	.....	.....	.....	.....	1	.....	1
Harrison	.....	.....	1	.....	.....	1	1	3	1	2	2	4
Hocking	7	1	3	2	2	1	4	6	6	6	6	.....
Holmes	1	.....	2	.....	.....	.....	5	.....	3	2	.....	2
Jackson	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	1
Jefferson	.....	.....	2	.....	4	1	1	.....	2	1	4	1
Knox	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	1
Licking	1	2	1	1	.....	.....	1	1	.....	2	.....	1
Lorain	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	1
Marion	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Medina	.....	.....	1	.....	1	4	.....	1	1	3	.....	2
Monroe	1	1	2	2	2	2	2	3	3	2	4	.....
Morgan	1	.....	2	2	7	1	10	2	9	4	13	1
Muskingum	.....	.....	4	3	5	.....	5	.....	4	.....	14	3
Noble	.....	.....	1	.....	5	4	6	3	7	6	9	2
Perry	6	1	3	.....	3	3	6	6	11	4	9	2
Richland	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
Vinton	.....	1	.....	.....	.....	2	.....	.....	.....	1	1	2
Washington	8	1	4	4	11	7	14	14	19	4	16	9
Wayne	1	2	.....	2	1	3	.....	2	3	2	3	8
	30	14	36	23	45	36	69	48	80	48	93	48

State.	July.		Aug.		Sept.		Oct.		Nov.		Dec.		Total.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Ashland	.....	.....	1	1	.....	3	.....	.....	.....	1	.....	2	1	14
Athens	1	2	8	1	2	2	4	5	9	1	2	2	37	21
Belmont	1	.....	4	1	3	.....	1	1	1	1	1	2	13	5
Carroll	6	.....	3	1	4	.....	2	1	5	2	3	1	41	8
Columbiana	.....	.....	.....	1	.....	2	1	.....	1	.....	.....	.....	5	6
Coshocton	5	1	5	.....	5	1	8	.....	4	1	6	.....	48	4
Cuyahoga	.....	2	.....	1	.....	.....	.....	1	.....	.....	.....	1	.....	18
Fairfield	.....	3	.....	.....	1	1	.....	.....	1	1	1	2	4	9
Harrison	3	1	2	4	2	2	3	.....	3	.....	1	2	19	19
Hocking	4	3	2	3	5	2	6	.....	4	3	4	2	58	29
Holmes	2	.....	.....	1	1	.....	1	.....	1	1	1	1	17	7
Jackson	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	3
Jefferson	2	1	.....	.....	2	.....	3	1	1	.....	1	1	22	6
Knox	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	1	1	1	4
Licking	.....	.....	1	.....	2	1	.....	.....	.....	1	.....	.....	6	9
Lorain	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3
Marion	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
Medina	.....	1	3	1	.....	3	7	4	2	2	8	1	23	22
Monroe	7	.....	5	.....	3	1	8	1	3	3	5	.....	45	15
Morgan	9	7	5	2	5	3	10	6	4	2	5	5	80	35
Muskingum	5	2	4	.....	3	.....	5	.....	2	.....	3	.....	54	8
Noble	5	1	9	1	6	4	.....	.....	5	5	4	2	57	28
Perry	8	3	11	3	13	3	12	1	5	2	5	2	92	30
Richland	.....	1	.....	.....	.....	.....	.....	.....	.....	1	.....	1	.....	5
Vinton	.....	2	.....	1	.....	2	2	1	.....	1	1	.....	4	13
Washington	18	11	10	8	15	10	8	6	13	6	14	9	150	89
Wayne	3	4	3	4	4	1	2	2	5	1	1	4	26	35
	79	46	76	35	76	41	83	30	69	36	67	41	803	446

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Wells completed in southeastern and central Ohio, 1914–1918.

Month.	Oil.					Dry.					Total completed.a				
	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918
January	105	55	66	54	30	52	42	40	40	14	197	198	144	123	92
February	86	39	56	65	36	51	29	41	27	23	165	158	144	119	89
March	76	49	60	74	45	29	42	37	37	36	121	166	125	148	104
April	112	58	74	81	69	54	40	44	39	48	193	152	135	146	143
May	100	50	97	86	80	50	36	53	56	48	190	123	176	183	170
June	88	50	92	80	93	48	31	48	54	48	182	134	168	186	187
July	83	47	101	75	79	57	36	51	41	46	224	119	185	156	162
August	70	51	89	67	76	56	52	51	38	35	180	161	177	144	157
September	27	54	77	83	76	28	27	44	58	41	142	139	163	185	152
October	42	61	71	66	83	37	35	33	43	30	151	158	133	146	145
November	32	79	64	82	69	35	54	43	48	36	148	218	151	179	156
December	42	84	80	55	67	20	48	40	23	41	151	184	153	113	138
	863	677	927	868	803	517	472	525	504	446	2,044	1,910	1,854	1,828	1,695

a Including gas wells.

Initial daily production of new wells completed in southeastern and central Ohio in 1918, in barrels.

County.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Ashland	.....	.....	.....	.....	.....	.....	.....	3	.....	.....	.....	.....	3
Athens	.....	4	.....	7	3	.....	2	13	3	7	15	3	57
Belmont	10	.....	.....	5	.....	.....	2	15	9	10	19	2	72
Carroll	15	50	14	95	82	43	59	9	33	11	15	22	448
Columbiana	2	.....	.....	.....	1	.....	.....	.....	.....	4	1	.....	8
Coshocton	.....	25	.....	105	76	75	33	51	47	55	39	72	578
Fairfield	.....	.....	10	.....	.....	.....	.....	.....	25	.....	10	10	55
Harrison	.....	5	.....	5	10	8	21	10	10	9	18	5	101
Hocking	304	416	50	210	250	214	175	25	112	338	75	203	2,372
Holmes	5	42	.....	142	81	.....	80	.....	50	25	100	3	528
Jefferson	.....	8	9	1	2	11	2	.....	7	5	1	1	47
Knox	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	10	10
Licking	20	50	.....	100	.....	.....	.....	5	102	.....	.....	.....	277
Medina	.....	35	5	.....	5	.....	.....	20	.....	70	21	78	234
Monroe	2	6	4	7	6	66	94	74	28	141	172	95	695
Morgan	2	7	19	28	40	28	21	14	13	33	22	10	237
Muskingum	.....	160	53	110	95	213	135	240	105	157	27	112	1,407
Noble	.....	1	44	33	62	46	35	19	76	.....	25	23	364
Perry	41	16	35	84	252	65	144	212	187	442	46	189	1,713
Vinton	.....	.....	.....	.....	.....	2	.....	.....	.....	12	.....	4	18
Washington	33	10	40	170	250	110	169	50	166	104	68	84	1,254
Wayne	25	.....	125	.....	93	200	230	215	95	85	465	8	1,541
	459	835	408	1,102	1,308	1,081	1,202	975	1,068	1,508	1,139	934	12,019

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Total and average initial daily production of new wells in southeastern and central Ohio, 1914–1918, by counties, in barrels.

County.	Total initial production.					Average per well.				
	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918
Ashland	50	5	10	.....	3	25.0	5.0	10.0	.....	3.0
Athens	14	42	33	66	57	2.0	2.6	2.1	2.1	1.5
Belmont	318	92	117	61	72	21.2	7.7	8.4	6.8	5.5
Carroll	72	126	133	1,013	448	2.5	5.3	7.0	25.3	10.9
Columbiana	278	93	23	35	8	4.8	2.5	1.4	1.8	1.6
Coshocton	82	.....	37	325	578	6.3	.....	9.3	27.1	12.0
Cuyahoga	78	216	286	98	.....	11.1	16.5	20.8	18.6	.....
Fairfield	530	97	127	55	55	21.2	8.1	9.8	11.0	13.8
Harrison	57	35	59	51	101	3.4	2.9	4.5	4.3	5.3
Hocking	4,711	3,816	3,261	2,777	2,372	48.6	53.7	34.3	39.1	40.9
Holmes	.....	.....	53	55	528	.....	.....	8.8	28.3	31.1
Jefferson	101	53	181	161	67	3.1	3.3	4.6	3.9	2.1
Knox	.....	109	73	266	10	.....	100.0	14.6	24.1	10.0
Licking	330	383	372	738	277	20.6	23.9	20.7	61.5	46.2
Marion	.....	.....	.....	10	.....	.....	.....	.....	10.0	.....
Medina	.....	35	60	42	234	.....	8.8	20.0	7.0	10.2
Monroe	348	338	282	133	605	6.8	9.4	6.4	4.0	15.4
Morgan	361	210	98	149	237	4.0	3.3	2.8	2.7	3.0
Muskingum	105	311	1,002	1,602	1,407	7.0	16.4	14.1	20.3	26.0
Noble	169	93	64	169	364	3.8	2.6	2.9	4.0	6.4
Perry	2,806	1,021	2,267	1,832	1,713	25.1	24.9	22.9	17.9	18.6
Tuscarawas	.....	.....	4	4	.....	.....	.....	2.0	2.0	.....
Vinton	.....	96	246	20	18	.....	16.0	9.8	5.0	4.5
Washington	1,307	1,210	1,796	1,634	1,254	5.9	5.0	5.5	6.5	8.4
Wayne	330	.....	25	686	1,541	36.7	.....	25.0	36.1	59.2
	12,047	8,373	10,838	11,976	12,019	14.0	12.4	11.7	13.8	15.0

Total initial daily production of new wells in southeastern and central Ohio, 1914–1918, by months, in barrels.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.	Monthly average.
1914	1,851	1,218	1,541	1,254	1,808	716	943	851	467	651	240	407	12,047	1,004
1915	668	642	498	534	723	777	466	345	782	675	901	1,377	8,373	698
1916	770	696	439	1,355	817	1,163	866	1,086	779	994	897	966	10,838	903
1917	773	934	982	1,204	1,180	1,134	1,398	1,120	1,021	616	1,025	589	11,976	998
1918	459	835	408	1,102	1,208	1,081	1,202	975	1,068	1,508	1,139	934	12,019	1,002

NORTHWESTERN DIVISION.

Wells completed in the northwestern (Lima) district, 1914–1918.

County.	Oil.					Dry.					Total completed.[a]				
	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918
Allen	71	9	35	26	28	4	.....	2	2	1	75	9	37	28	29
Auglaize	24	4	13	28	32	6	3	10	4	5	30	8	23	35	38
Champaign	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	1	.....
Crawford	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	1	1	.....
Darke	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	1	.....
Defiance	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	1
Erie	.....	.....	.....	.....	.....	.....	2	.....	.....	.....	.....	2	.....	.....	1
Fulton	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	54
Hancock	120	36	106	78	51	19	4	5	8	.....	144	40	114	84	.....
Hardin	2	.....	.....	.....	.....	2	.....	.....	.....	.....	4	.....	1	.....	.....
Henry	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....
Lucas	39	3	5	2	4	3	1	.....	.....	2	42	6	5	2	7
Marion	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....
Mercer	15	3	51	35	29	2	1	7	8	3	17	4	59	44	32
Ottawa	17	4	25	39	40	.....	.....	.....	2	1	17	5	26	41	42
Putnam	3	.....	.....	.....	.....	.....	.....	1	.....	.....	3	.....	1	.....	.....
Sandusky	145	27	79	61	32	6	1	5	2	.....	152	28	85	63	32
Seneca	23	17	53	30	31	6	6	15	6	13	29	23	68	36	44
Shelby	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....
Van Wert	41	5	33	29	32	2	1	5	5	4	45	6	38	34	36
Williams	.....	.....	.....	.....	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	2
Wood	263	116	216	148	88	19	7	21	11	6	288	127	240	161	96
Wyandot	.....	.....	.....	1	.....	.....	1	1	1	2	2	3	1	2	2
	765	224	616	473	369	69	27	72	52	38	850	261	699	534	416

[a] Including gas wells.

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Oil wells and dry holes drilled in the northwestern (Lima) district in 1918.

County.	Jan.		Feb.		Mar.		Apr.		May.		June.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Allen	1	.....	.....	.....	3	.....	2	.....	5	.....	4	.....
Auglaize	3	.....	.....	.....	3	.....	3	.....	6	2	5	.....
Defiance	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....
Hancock	1	.....	.....	.....	2	.....	5	.....	4	.....	6	.....
Lucas	.....	.....	.....	.....	.....	.....	.....	.....	1	1	1	.....
Mercer	1	.....	.....	.....	3	.....	3	.....	3	.....	1	.....
Ottawa	.....	.....	2	.....	2	.....	4	.....	6	.....	3	.....
Sandusky	3	.....	1	.....	3	.....	3	.....	3	.....	4	.....
Seneca	1	.....	.....	1	1	1	3	.....	2	2	2	1
Van Wert	1	.....	.....	.....	2	1	1	.....	6	2	2	.....
Williams	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....
Wood	4	.....	1	.....	9	.....	8	1	8	1	8	.....
Wyandot	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....
	15	.....	4	1	28	2	33	2	49	9	36	1

County.	July.		Aug.		Sept.		Oct.		Nov.		Dec.		Total.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Allen	3	.....	4	.....	2	1	1	.....	2	.....	1	.....	28	1
Auglaize	6	1	4	1	1	.....	.....	.....	.....	1	1	.....	32	5
Defiance	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
Hancock	7	.....	6	.....	5	.....	3	.....	8	.....	4	.....	51	.....
Lucas	.....	1	.....	.....	.....	.....	1	.....	1	.....	.....	.....	4	2
Mercer	2	1	2	.....	2	1	4	.....	5	.....	3	1	29	3
Ottawa	5	.....	4	.....	4	1	2	.....	3	.....	5	.....	40	1
Sandusky	4	.....	3	.....	.....	.....	1	.....	1	.....	1	.....	32	.....
Seneca	1	2	5	.....	4	1	5	2	4	2	3	1	31	13
Van Wert	5	.....	5	.....	3	1	3	.....	2	.....	2	.....	32	4
Williams	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2	.....
Wood	10	.....	12	1	5	2	6	.....	8	1	9	.....	88	6
Wyandot	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2
	44	6	45	2	26	7	26	2	34	4	29	2	369	38

Wells completed in the northwestern (Lima) district, 1914–1918.

Month.	Oil.					Dry.					Total completed.[a]				
	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918
January	84	9	27	31	15	5	1	6	.....	.....	91	10	34	31	15
February	74	19	21	26	4	6	3	5	3	1	82	24	28	29	5
March	65	12	45	38	28	3	2	2	7	2	70	15	47	46	30
April	63	18	56	36	33	11	2	5	5	2	74	20	62	41	35
May	94	15	57	46	49	10	2	8	6	9	104	18	65	54	59
June	75	13	65	49	36	14	2	8	4	1	89	16	73	54	40
July	75	12	63	41	44	4	6	8	2	6	80	21	71	46	52
August	71	21	72	48	45	4	4	6	6	2	76	25	78	56	47
September	66	22	59	43	26	5	.....	10	7	7	72	22	71	50	33
October	39	21	52	46	26	6	2	5	6	2	49	24	59	52	28
November	25	38	64	40	34	.....	.....	8	3	4	26	39	74	43	41
December	34	24	35	29	29	1	2	1	3	2	37	27	37	32	31
	765	224	616	473	369	69	27	72	52	38	850	261	699	534	416

[a] Including gas wells.

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Initial daily production of new wells completed in the northwestern (Lima) district in 1918, in barrels.

County.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Allen	15	.....	54	20	60	35	30	30	15	15	15	12	301
Auglaize	18	.....	21	6	32	34	40	36	5	.....	.....	5	197
Hancock	5	.....	15	30	48	60	43	81	115	24	120	62	603
Lucas	.....	.....	.....	.....	1	10	.....	.....	.....	8	6	.....	25
Mercer	15	.....	30	36	28	20	28	15	70	75	50	55	422
Ottawa	.....	42	25	30	76	30	33	47	25	15	21	48	392
Sandusky	17	15	15	30	38	26	16	30	.....	10	5	6	208
Seneca	50	.....	10	165	115	255	20	92	395	168	164	40	1,474
Van Wert	25	.....	12	10	45	10	88	70	23	20	10	50	363
Williams	.....	.....	.....	2	.....	.....	10	.....	.....	.....	.....	.....	12
Wood	43	5	135	60	87	71	286	237	47	235	105	192	1,503
	188	62	317	389	530	551	594	638	695	570	496	470	5,500

Total and average initial daily production of new wells in the northwestern (Lima) district, 1914–1918, by counties, in barrels.

County.	Total initial production.					Average per well.				
	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918
Allen	762	120	440	325	301	10.7	13.3	12.6	12.5	10.8
Auglaize	285	25	202	368	197	11.9	6.3	15.5	13.1	6.2
Hancock	1,543	422	1,414	1,305	603	12.9	11.7	13.3	17.9	11.8
Hardin	61	.....	.....	.....	.....	30.5	.....	.....	.....	.....
Henry	3	.....	.....	.....	.....	3.0	.....	.....	.....	.....
Lucas	792	26	39	9	25	20.3	8.7	7.8	4.5	6.3
Marion	.....	.....	.....	10	.....	.....	.....	.....	10.0	.....
Mercer	183	38	1,084	486	422	12.2	12.7	21.3	13.9	14.6
Ottawa	117	46	265	408	392	6.9	11.5	10.6	10.5	9.8
Putnam	43	.....	.....	.....	.....	14.3	.....	.....	.....	.....
Sandusky	764	106	537	424	208	5.3	3.9	6.8	7.0	6.5
Seneca	713	1,554	1,587	1,343	1,474	31.0	91.4	29.9	44.8	47.6
Shelby	10	.....	.....	.....	.....	10.0	.....	.....	.....	.....
Van Wert	530	58	800	416	363	12.7	11.6	24.2	14.4	11.3
Williams	.....	.....	.....	.....	12	.....	.....	.....	.....	6.0
Wood	3,523	2,101	2,957	2,264	1,503	13.4	18.1	13.7	15.3	17.1
Wyandot	.....	.....	.....	6	.....	.....	.....	.....	6.0	.....
	9,329	4,496	9,325	7,364	5,500	12.2	20.1	15.1	15.6	14.9

Total daily production of new wells in the northwestern (Lima) district, 1914–1918, by months, in barrels.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.	Monthly average.
1914	959	916	1,057	759	967	1,088	1,117	657	697	277	221	614	9,329	777
1915	68	845	178	332	168	287	141	273	700	592	666	246	4,496	375
1916	482	475	742	859	730	980	944	947	759	861	957	589	9,325	777
1917	427	552	661	860	582	646	552	812	608	605	677	382	7,364	614
1918	188	62	317	389	530	551	594	638	695	570	496	470	5,500	458

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LIMA-INDIANA OIL FIELD.[1]

GENERAL STATEMENT.

The Lima-Indiana field embraces all areas of production of oil in northwestern Ohio and northeastern Indiana. In this field the oil occurs in low domes over the broad crest of the Cincinnati uplift or in domes, terraces, or other minor convexities on its flanks. The oil-bearing strata consist of lenses or discontinuous layers in the "Trenton" limestone, of Ordovician age, in which the original limestone has been changed to a porous dolomite. Wherever the "Trenton" limestone ceases to be dolomitic it ceases to be oil bearing. The pools in the "Trenton" rock district are very irregular in shape, differ greatly in size, and in many places entirely surround barren areas.

In southwestern Indiana there are a number of detached pools in which oil is obtained from the "Corniferous" limestone of the Devonian system and from sandstone in the Chester group of the Mississippian series (lower Carboniferous).

The Lima-Indiana oil field as a whole showed a marked decrease in production in 1918, as compared with previous years. The output of 3,220,722 barrels was less than that of 1917 by more than 12 per cent—or more than twice the rate of decline in 1917. The decline, however, was in the old Lima field, which showed a production of 2,343,164 barrels, a decrease of 19.5 per cent from the production in 1917. The Indiana fields, on the other hand, showed an increase of more than 15 per cent to 877,558 barrels. The year brought a considerable amount of development work in the old producing field in the eastern-central part of Indiana, but western Indiana, along the Illinois line in the vicinity of Princeton and Oakland City, was also active and showed an increase in production. The Oakland City field showed the most wells and the best production.

The average price per barrel received at the wells for all grades of Lima-Indiana crude was $2.31, an advance of 38 cents over the average price in 1917 and 75 cents over the average in 1916. The market value of the output in 1918—$7,450,932—was nearly 5 per cent greater than that of the output in 1917, although the quantity was 12 per cent less.

DEVELOPMENT.

New wells to the number of 693 were completed in the Lima-Indiana field during 1918, compared with 800 in 1917 and 965 in 1916. Of the wells completed in 1918, 138, or 20 per cent, were dry holes. However, 36 per cent of the wells drilled in Indiana were dry holes, as compared with only 9 per cent in the old Lima field. To offset this, the average initial daily production of the oil wells in Indiana was 27 barrels, as compared with 14.9 barrels in the Lima field.

[1] Some statistics for the Lima portion of this field are given under Ohio (pp. 1030–1032).

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PETROLEUM PRODUCED.

Petroleum produced in the Lima-Indiana field in 1917 and 1918, in barrels.

Month.	1917			1918		
	Lima, Ohio.	Indiana.	Total.	Lima, Ohio.	Indiana.	Total.
January	250,916	64,259	315,175	120,207	48,779	168,986
February	208,869	54,593	263,462	164,984	64,546	229,530
March	273,073	62,038	335,111	217,328	75,724	293,052
April	250,248	59,497	309,745	214,746	80,677	295,423
May	270,702	67,327	338,029	231,163	85,353	316,516
June	266,256	63,306	329,562	207,362	75,621	282,983
July	252,104	65,120	317,224	217,391	81,295	298,686
August	253,704	65,527	319,231	211,306	75,955	287,261
September	223,109	62,992	286,092	187,605	67,235	254,840
October	244,957	70,282	315,239	206,196	77,124	283,320
November	231,764	67,808	299,572	175,802	72,692	248,494
December	185,096	56,683	241,699	189,774	71,957	261,731
	2,910,861	759,432	3,670,293	2,343,164	877,558	3,220,722

Petroleum produced in the Lima-Indiana field since 1886.

Year.	Quantity (barrels).	Percentage of total production of United States.	Increase or decrease.		Value.	Yearly average price per barrel.
			Barrels.	Per cent.		
1886	1,137,869	4.06	.....	.....	$444,198	$0.390
1887	4,650,375	14.44	+3,512,506	+308.69	953,327	.205
1888	9,682,663	25.07	+5,032,308	+108.21	1,452,402	.150
1889	12,186,564	24.66	+2,503,901	+ 25.86	1,833,859	.150
1890	15,078,378	22.91	+2,891,814	+ 23.73	4,536,927	.301
1891	17,452,612	32.15	+2,374,234	+ 15.75	5,333,797	.306
1892	15,867,575	31.41	−1,585,037	− 9.08	5,814,630	.366
1893	15,982,097	33.00	+ 114,522	+ .75	7,497,597	.469
1894	17,296,510	35.06	+1,314,413	+ 8.22	8,306,025	.480
1895	20,236,741	38.26	+2,940,231	+ 17.00	14,184,256	.700
1896	25,255,870	41.43	+5,019,129	+ 24.80	16,678,028	.660
1897	22,805,033	37.71	−2,450,837	− 9.70	10,848,097	.476
1898	20,321,323	36.71	−2,483,710	− 10.89	12,458,904	.613
1899	20,225,356	35.44	− 95,967	− .47	18,082,723	.894
1900	21,758,750	34.20	+1,533,394	+ 7.58	21,367,287	.982
1901	21,933,379	31.61	+ 174,629	+ .80	18,734,438	.854
1902	28,358,626	36.31	+1,425,247	+ 6.50	20,810,094	.880
1903	24,080,264	23.97	+ 721,638	+ 3.09	27,825,466	1.155
1904	24,689,184	21.09	+ 608,920	+ 2.53	26,970,803	1.092
1905	22,294,171	16.55	−2,395,013	− 9.70	19,466,901	.873
1906	17,554,661	13.88	−4,739,510	− 21.26	15,927,707	.907
1907	13,121,094	7.90	−4,433,567	− 25.26	11,962,410	.912
1908	10,032,305	5.82	−3,088,789	− 23.54	10,065,768	1.003
1909	8,211,443	4.48	−1,820,862	− 18.15	7,449,107	.907
1910	7,253,861	3.46	− 957,582	− 11.66	5,750,184	.793
1911	6,231,164	2.83	−1,022,697	− 14.10	5,116,954	.821
1912	a 4,925,906	2.21	−1,305,258	− 20.95	4,794,784	.983
1913	4,773,138	1.93	− 152,768	− 3.10	6,588,068	1.380
1914	5,062,543	1.90	+ 289,405	+ 6.07	5,983,356	1.182
1915	4,269,591	1.82	− 792,952	− 15.66	4,114,228	.964
1916	3,905,003	1.298	− 364,588	− 8.54	6,117,269	1.567
1917	3,670,293	1.09	− 234,710	− 6.01	7,102,326	1.935
1918	3,220,722	.90	− 449,571	− 12.25	7,450,492	2.313
	448,525,084	9.73	.....	.....	342,023,371	.763

a Includes production in Michigan.

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Petroleum produced in the Lima-Indiana field in 1917 and 1918, by districts.

District.	Quantity (barrels).		Increase or decrease.	
	1917	1918	Barrels.	Per cent.
Lima, Ohio	2,910,861	2,343,164	−567,697	−19.50
Indiana	759,432	877,558	+118,126	+15.55
	3,670,293	3,220,722	−449,571	−12.25

Petroleum produced, value, and average price per barrel in the Lima-Indiana field, 1909–1918.

Year.	Lima, Ohio.			Indiana.			Total.		
	Quantity (barrels).	Value.	Average price per barrel.	Quantity (barrels).	Value.	Average price per barrel.	Quantity (barrels).	Value.	Average price per barrel.
1909	5,915,357	$5,451,497	$0.921	2,296,086	$1,997,610	$0.870	8,211,443	$7,449,107	$0.907
1910	5,094,136	4,181,629	.821	2,159,725	1,568,475	.726	7,253,861	5,750,104	.793
1911	4,535,875	3,898,119	.857	1,695,289	1,228,835	.725	6,231,164	5,116,954	.821
1912	a3,955,897	3,906,809	.988	970,009	885,975	.913	4,925,906	4,794,784	.932
1913	3,817,043	5,306,842	1.391	956,695	1,279,226	1.337	4,773,738	6,588,068	1.380
1914	3,727,087	4,435,314	1.190	1,335,456	1,548,042	1.159	5,062,543	5,983,356	1.182
1915	3,393,833	3,300,833	.973	875,758	813,395	.929	4,269,591	4,114,228	.964
1916	3,135,967	4,909,704	1.566	769,036	1,207,565	1.570	3,905,003	6,117,269	1.567
1917	2,910,861	5,631,778	1.935	759,432	1,470,548	1.936	3,670,293	7,102,326	1.935
1918	2,343,164	5,422,803	2.314	877,558	2,028,129	2.311	3,220,722	7,450,932	2.313

a Includes production of Michigan.

Petroleum produced in the Lima-Indiana field, 1914–1918, in barrels.

Month.	1914	1915	1916	1917	1918
January	451,053	353,827	304,554	315,175	168,986
February	326,355	360,140	313,266	263,462	229,430
March	463,922	388,034	348,912	335,111	293,052
April	465,415	396,458	334,687	309,745	285,423
May	457,749	358,944	357,042	338,029	316,516
June	460,915	374,312	346,931	329,662	282,983
July	458,553	364,167	331,463	317,286	298,686
August	429,468	341,804	342,290	319,231	287,261
September	422,501	339,608	317,500	286,092	254,840
October	420,495	344,964	326,269	315,239	283,320
November	363,741	319,644	305,819	299,572	248,494
December	342,376	328,199	276,270	241,689	261,731
	5,062,543	4,269,591	3,905,003	3,670,293	3,220,722

Average daily output of petroleum in the Lima-Indiana field, 1914–1918, in barrels.

Month.	1914	1915	1916	1917	1918
January	14,550	11,414	9,824	10,167	5,451
February	11,656	12,862	10,802	9,409	8,194
March	14,965	12,517	11,255	10,810	9,453
April	15,514	13,215	11,156	10,325	9,847
May	14,766	11,579	11,518	10,904	10,210
June	15,364	12,477	11,564	10,989	9,433
July	14,792	11,747	10,692	10,234	9,635
August	13,854	11,029	11,042	10,298	9,266
September	14,083	11,300	10,583	9,536	8,495
October	13,564	11,128	10,525	10,107	9,139
November	12,125	10,655	10,194	9,986	8,283
December	11,044	10,587	8,912	7,796	8,443
Average	13,870	11,698	10,669	10,052	8,824

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PIPE-LINE RUNS, DELIVERIES, AND STOCKS.

Pipe-line runs in the Lima-Indiana field in 1917 and 1918, in barrels.

Month.	Buckeye pipe line.	Other Ohio lines.	Indiana pipe line.	Other Indiana lines.	Total.
1917.					
January	169,642	81,274	21,668	42,591	315,175
February	138,895	69,974	17,692	36,901	263,462
March	185,901	87,172	18,516	43,522	335,111
April	164,303	85,945	20,676	38,821	309,745
May	181,347	89,355	21,259	46,068	338,029
June	172,361	93,995	20,250	43,056	329,662
July	167,428	84,738	20,403	44,717	317,286
August	170,026	83,678	19,583	45,944	319,231
September	146,793	76,307	17,181	45,811	286,092
October	164,157	80,800	18,507	51,775	315,239
November	152,932	78,832	15,326	52,482	299,572
December	122,129	62,877	13,463	43,220	241,689
	1,935,914	974,947	224,524	534,908	3,670,293
1918.					
January	87,476	32,731	7,935	40,844	168,986
February	117,443	47,441	13,434	51,112	229,430
March	152,911	64,417	16,188	59,536	293,052
April	150,523	64,223	18,483	62,194	295,423
May	164,468	66,695	18,858	66,495	316,516
June	145,545	61,817	15,278	60,343	282,983
July	155,441	61,950	19,241	62,054	298,686
August	148,072	63,234	18,735	57,220	287,261
September	130,519	56,486	16,096	51,739	254,840
October	147,292	58,904	18,908	58,216	283,320
November	122,751	53,051	18,678	54,014	248,494
December	134,499	55,275	17,216	54,741	261,731
	1,656,940	686,224	199,050	678,508	3,220,722

Pipe-line runs and deliveries to trade of Lima-Indiana oil and stocks at end of each month in 1917 and 1918, in barrels.

Month.	1917			1918		
	Runs.	Deliveries.	Stocks.	Runs.	Deliveries.	Stocks.
Dec. 31, 1916			2,088,365			
January	315,175	126,898	2,276,642	168,986	368,862	1,706,365
February	263,462	201,433	2,338,671	229,430	445,862	1,489,933
March	335,111	184,229	2,489,553	293,052	314,822	1,468,163
April	309,745	401,993	2,397,305	295,423	301,131	1,462,455
May	338,029	477,885	2,257,449	316,516	316,755	1,462,216
June	329,662	419,953	2,167,158	282,983	412,225	1,332,974
July	317,286	355,425	2,129,019	298,686	365,201	1,266,459
August	319,231	388,873	2,059,377	287,261	339,692	1,214,028
September	286,092	435,522	1,909,947	254,840	331,915	1,136,953
October	315,239	304,582	1,920,604	283,320	299,835	1,120,438
November	299,572	238,521	1,981,655	248,494	315,760	1,053,172
December	241,689	317,103	1,906,241	261,781	286,095	1,028,808
	3,670,293	3,852,417		3,220,722	4,098,155	

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PRICES.

Prices of Lima and Indiana petroleum in 1916–1918, per barrel.

1916				1917				1918			
Date.	Lima.	Indiana.	Princeton, Ind.	Date.	Lima.	Indiana.	Princeton, Ind.	Date.	Lima.	Indiana.	Princeton, Ind.
Jan. 1	$1.33	$1.18	$1.47	Jan. 1	$1.58	$1.43	$1.62	Jan. 1	$2.08	$1.98	$2.12
Jan. 3	1.43	1.28	1.57	Jan. 2	1.58	1.53	1.72	Feb. 9	2.18	2.08	2.22
Jan. 22	1.48	1.33	.....	Jan. 8	1.78	1.63	1.82	Mar. 21	2.28	2.18	2.32
Jan. 27	1.53	1.38	1.62	Jan. 27	.....	1.68	.....	July 9	2.38	2.28	2.42
Feb. 7	1.58	1.43	.....	Jan. 30	1.83	1.73	1.87				
Feb. 16	.....	.....	1.72	Apr. 16	1.88	1.78	1.92				
Mar. 7	1.63	1.48	.....	May. 15	.....	.....	2.18				
Mar. 16	1.73	1.58	1.82	Aug. 16	2.08	1.98	2.12				
July 28	1.63	1.48	1.72								
Aug. 1	1.58	1.43	1.60								
Aug. 4	1.48	1.33	1.52								
Aug. 14	1.43	1.28	1.47								
Nov. 18	1.48	1.33	1.52								
Dec. 13	1.53	1.38	1.57								
Dec. 19	1.58	1.43	1.62								

Average monthly prices of Lima and Indiana petroleum in 1916, 1917, and 1918, per barrel.

Month.	1916			1917			1918		
	Lima.	Indiana.	Princeton, Ind.	Lima.	Indiana.	Princeton, Ind.	Lima.	Indiana.	Princeton, Ind.
January	$1.45	$1.30	$1.57	$1.75	$1.62	$1.79	$2.08	$1.98	$2.12
February	1.57	1.42	1.67	1.83	1.73	1.87	2.15	2.05	2.19
March	1.67	1.52	1.77	1.83	1.73	1.87	2.22	2.12	2.26
April	1.73	1.58	1.82	1.86	1.76	1.90	2.28	2.18	2.32
May	1.73	1.58	1.82	1.88	1.78	2.06	2.28	2.18	2.32
June	1.73	1.58	1.82	1.88	1.78	2.18	2.28	2.18	2.32
July	1.72	1.57	1.81	1.88	1.78	2.18	2.35	2.25	2.39
August	1.46	1.31	1.50	1.98	1.88	2.15	2.38	2.28	2.42
September	1.43	1.28	1.47	2.08	1.98	2.12	2.38	2.28	2.42
October	1.43	1.28	1.47	2.08	1.98	2.12	2.38	2.28	2.42
November	1.45	1.30	1.49	2.08	1.98	2.12	2.38	2.28	2.42
December	1.53	1.38	1.57	2.08	1.98	2.12	2.38	2.28	2.42
Average	1.58	1.43	1.67	1.93	1.83	2.04	2.30	2.20	2.34
Average of North Lima and South Lima and Indiana	1.51			1.98			2.25		

Highest, lowest, and average prices of Lima (Ohio) petroleum, 1909–1918, per barrel.

Year.	Highest.	Lowest.	Average.	Year.	Highest.	Lowest.	Average.
1909	[a] $1.04	[b] $0.79	$0.906	1914	[a] $1.49	[b] $0.88	$1.17
1910	[a] .84	[b] .77	.804	1915	[a b] 1.33	[b] .88	.96
1911	[a] .84	[b] .77	.801	1916	[a b] 1.73	[a b] 1.33	1.58
1912	[a] 1.25	[b] .79	.998	1917	[a b] 2.08	1.58	1.93
1913	[a] 1.49	[b] 1.20	1.375	1918	[a b] 2.38	2.08	2.30

[a] North Lima. [b] South Lima.

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SUMMARY OF WELLS DRILLED.

The statistics of field operations presented in the following tables are compiled from trade-journal sources and differ somewhat from those on pages 986–987, which are obtained from reports received directly from the oil producers:

Wells completed in the Lima-Indiana field, 1914–1918.

District.	Oil.					Dry.					Total completed.[a]				
	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918
Lima	765	224	616	473	369	69	27	72	52	38	850	261	699	534	416
Indiana	470	98	160	174	169	259	86	98	83	100	742	192	266	266	277
	1,235	322	776	647	538	328	118	170	135	138	1,592	453	965	800	693

[a] Including gas wells.

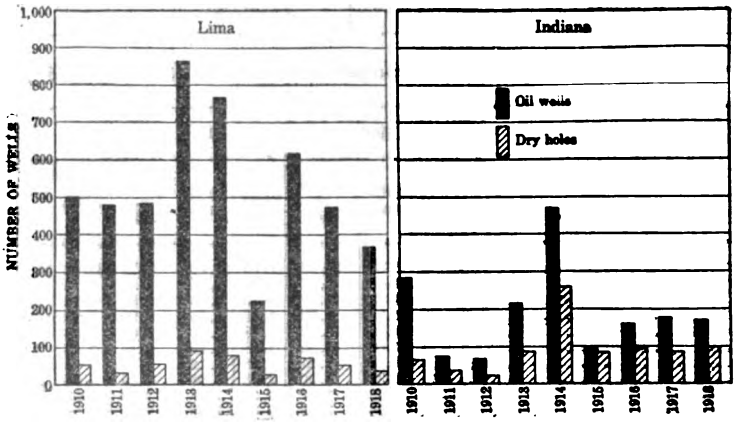

FIGURE 105.—Comparison of number of producing oil wells with dry holes drilled in the Lima-Indiana field, 1910–1918.

Oil wells and dry holes drilled in the Lima-Indiana field in 1918.

District.	Jan.		Feb.		Mar.		Apr.		May.		June.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Lima	15	.....	4	1	28	2	33	2	49	9	36	1
Indiana	6	.....	7	4	17	10	11	5	9	10	22	13
	21	.....	11	5	45	12	44	7	58	19	58	14

District.	July.		Aug.		Sept.		Oct.		Nov.		Dec.		Total.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Lima	44	6	45	2	26	7	26	2	34	4	29	2	369	38
Indiana	20	17	11	13	21	6	12	2	19	12	14	8	169	100
	64	23	56	15	47	13	38	4	53	16	43	10	538	138

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Wells completed in the Lima-Indiana field, 1914–1918.

Month.	Oil.					Dry.					Total completed.[a]				
	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918
January	120	14	36	37	21	22	10	12	4	.....	145	24	50	42	21
February	119	29	30	32	11	31	5	12	6	5	153	38	45	40	17
March	107	23	58	52	45	33	5	13	8	12	144	30	73	61	57
April	107	29	65	49	44	38	9	18	12	7	145	38	84	61	53
May	168	22	79	57	58	37	9	22	15	19	208	32	102	75	78
June	154	19	87	64	58	48	10	18	13	14	202	30	105	79	76
July	129	20	78	59	64	30	16	18	13	23	162	40	96	75	89
August	111	23	86	61	56	36	10	13	13	15	139	34	99	78	72
September	89	27	74	57	47	25	12	15	13	13	115	41	92	70	62
October	49	27	68	75	38	13	8	7	16	4	67	36	77	91	42
November	33	48	73	60	53	11	13	16	11	16	47	62	92	73	73
December	49	41	42	44	43	14	6	6	11	10	65	48	50	55	53
	1,235	322	776	647	538	328	113	170	135	138	1,592	453	965	800	693

[a] Including gas wells.

Initial daily production of new wells completed in the Lima-Indiana field in 1918, in barrels.

District.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Lima	188	62	317	389	530	551	594	638	695	570	496	470	5,500
Indiana	60	340	467	406	304	464	447	234	376	526	693	251	4,568
	248	402	784	795	834	1,015	1,041	872	1,071	1,096	1,189	721	10,068

Total and average initial daily production of new wells in the Lima-Indiana field, 1914–1918, by districts, in barrels.

District.	Total initial production.					Average per well.				
	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918
Lima	9,329	4,496	9,325	7,364	5,500	12.2	20.1	15.1	15.6	14.9
Indiana	8,436	2,564	3,554	4,914	4,568	18.0	26.2	22.2	28.2	27.0
	17,765	7,060	12,879	12,278	10,068	14.4	21.9	16.6	19.0	18.7

Total initial daily production of new wells in the Lime-Indiana field, 1914–1918, by months, in barrels.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.	Monthly average.
1914	1,636	2,129	2,187	1,859	1,944	2,245	1,928	1,067	969	431	372	898	17,765	1,480
1915	130	960	329	502	305	512	269	288	829	919	1,109	908	7,060	588
1916	778	657	1,634	1,607	1,218	1,504	1,226	1,164	1,285	1,182	1,162	702	12,879	1,073
1917	660	658	942	1,163	1,014	1,192	1,045	1,156	1,061	1,367	1,107	973	12,278	1,023
1918	248	402	784	795	834	1,015	1,041	872	1,071	1,096	1,189	721	10,068	839

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Oil wells abandoned in the Lima-Indiana field from June, 1905, to December, 1918, by months.

Month.	1905	1906	1907	1908	1909	1910	1911	1912	1913	1914	1915	1916	1917	1918	Total.
January	.....	54	45	75	149	61	62	59	17	7	50	13	72	4	668
February	.....	74	83	59	108	66	21	34	21	4	31	28	14	21	564
March	.....	27	49	129	237	221	114	28	13	30	86	24	123	2	1,063
April	.....	47	129	198	98	140	31	86	47	23	55	5	100	23	982
May	.....	100	194	358	204	457	233	83	37	74	88	7	50	.....	1,585
June	28	82	143	207	347	146	118	122	101	52	63	104	148	21	1,682
July	53	50	111	191	157	176	141	75	17	82	34	26	37	6	1,156
August	54	147	170	228	322	126	122	102	71	100	34	15	116	4	1,611
September	19	87	157	195	267	294	79	117	127	64	33	54	112	21	1,626
October	158	139	181	144	201	80	137	66	142	59	18	161	72	10	1,568
November	53	139	177	155	172	100	160	158	38	176	63	80	51	23	1,545
December	66	117	62	220	156	128	41	80	40	29	59	.....	72	1	1,071
Total, Indiana	431	1,063	1,501	2,159	2,418	1,695	1,259	1,010	671	700	614	517	967	136	15,141
Total, Lima	674	1,059	1,357	1,135	1,127	1,500	1,142	856	601	486	664	668	1,245	770	13,284
Total, Lima-Indiana	1,105	2,122	2,858	3,294	3,545	3,195	2,401	1,866	1,272	1,186	1,278	1,185	2,212	906	28,425

Oil wells abandoned in the Lima-Indiana field, June, 1905, to Dec. 31, 1918, by counties.

Lima.		Indiana.	
County.	Number of wells.	County.	Number of wells.
Allen	2,680	Adams	1,237
Auglaize	939	Allen	1
Darke	4	Blackford	1,433
Hancock	1,720	Delaware	1,425
Lucas	613	Gibson	28
Mercer	572	Grant	4,420
Ottawa	417	Hamilton	9
Putnam	25	Huntington	1,020
Sandusky	1,183	Jay	992
Seneca	126	Knox	14
Shelby	13	Madison	87
Van Wert	890	Marion	15
Wood	3,764	Miami	49
Wyandot	338	Pike	58
		Randolph	223
		Sullivan	1
		Wabash	16
		Wells	4,114
	13,284		15,141

INDIANA.

GENERAL STATEMENT.

Indiana showed an increase in production in 1918, the output of 877,558 barrels being greater by 118,126 barrels, or 15.5 per cent, than in 1917. This increase in production is credited to increased drilling activity, especially in the old "Trenton" area in the northeastern part of the State and to a marked decrease in the number of wells abandoned. The value of the Indiana output—$2,028,129—was greater by $557,581 in 1918 than in 1917.

DEVELOPMENT.

The greatest activity in the drilling of new wells was in the northeastern counties where the oil is obtained principally from dolomite lenses in the "Trenton" limestone. In this area 124 wells were completed, more than twice the number of completions in 1917 and more than six times the number in 1916. Of the wells drilled in

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1918, 27 per cent were dry holes as compared with 47 per cent in 1917. The most marked increase in drilling activity was in Huntington, Randolph, and Delaware counties. Initial production of 100 barrels or more was reported for four wells in Delaware County and for one well in Huntington County. The largest well in the State was the George D. Roberts well No. 6 on the Tripple tract in Delaware County, which had an initial production of 200 barrels.

In the southwestern part of the State new wells were drilled in Gibson, Pike, and Sullivan counties, chief interest being centered in the vicinity of Princeton and Oakland City in Gibson County. In these three counties, however, only 152 wells were completed, as compared with 187 in 1917 and 220 in 1916.

For the State as a whole, 277 wells were completed, as compared with 266 in 1917 and 266 in 1916. Of these wells 169, or 61 per cent, were oil wells, 100 were dry holes, and 8 were gas wells; and as 135 wells were abandoned during the year, there was an increase of 34 in the number of producing oil wells.

PETROLEUM PRODUCED.

Petroleum produced in Indiana, 1914–1918, in barrels.

Month.	1914	1915	1916	1917	1918
January	109,891	82,390	57,063	64,259	48,779
February	97,045	85,690	60,731	54,593	64,546
March	120,508	76,939	61,260	59,497	75,724
April	126,670	82,683	63,195	62,038	80,677
May	128,493	75,922	69,660	67,327	85,353
June	129,855	78,934	69,725	63,306	75,621
July	121,122	72,189	66,191	65,120	81,295
August	109,939	66,452	72,841	65,527	75,955
September	110,299	62,010	67,462	62,992	67,835
October	105,969	66,332	65,937	70,282	77,124
November	88,272	58,447	57,596	67,808	72,692
December	87,333	67,770	57,375	56,683	71,957
	1,335,456	875,758	769,036	759,432	877,558

SUMMARY OF WELLS DRILLED.

The statistics of field operations presented in the following tables are compiled from trade-journal sources and differ somewhat from those on page 987, which are obtained from reports received directly from the oil producers:

Wells completed in Indiana, 1914–1918.

County.	Oil.					Dry.					Total completed.[a]				
	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918
Adams	4	.....	.....	.....	5	.....	.....	.....	.....	1	4	.....	.....	.....	6
Allen	.....	.....	.....	8	3	.....	.....	.....	.....	.....	.....	.....	.....	8	3
Blackford	1	.....	3	1	1	.....	.....	3	1	1	3	.....	6	2	2
Clay	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	1	.....	.....	.....
Daviess	.....	1	2	.....	.....	.....	3	.....	.....	.....	.....	4	2	.....	.....
Decatur	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....
Delaware	24	1	1	1	17	8	.....	.....	2	5	32	2	1	3	22
Dubois	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	1	.....	.....	.....	.....
Gibson	3	4	14	21	16	.....	5	5	7	15	3	9	19	33	34
Grant	3	.....	3	3	5	.....	1	.....	.....	2	4	1	3	3	7
Harrison	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	2	.....	.....	.....	.....
Huntington	.....	.....	.....	.....	22	.....	.....	.....	1	6	.....	.....	.....	1	28
Jay	14	1	2	17	8	4	.....	2	21	10	21	2	4	38	18
Knox	.....	1	.....	2	.....	6	5	.....	1	.....	6	6	.....	3	.....

[a] Including gas wells.

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Wells completed in Indiana, 1914–1918—Continued.

County.	Oil.					Dry.					Total completed.				
	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918
Madison									1					1	1
Marion					1										1
Martin						1					1				
Miami			6	12		2		4	3		2		10	15	
Pike	6	9	38	75	53	8	12	28	24	24	14	22	69	103	79
Putnam							1					1			
Randolph	4	1	1	1	21	1		2	3	4	7	2	3	4	26
Shelby	4	1									4	1			
Spencer			1					1					2		
Sullivan	400	66	79	33	11	219	52	49	18	27	624	122	132	51	39
Vanderburg										1					1
Vigo	3	13	8			2	4	3			5	17	11		
Wabash	1								1		1			1	
Warrick							2	1				2	1		
Wells	1		2		6					4	1		2		10
Miscellaneous						7					7				
	470	98	160	174	169	259	86	98	83	100	742	192	266	266	277

Oil wells and dry holes drilled in Indiana in 1918.

County.	Jan.		Feb.		Mar.		Apr.		May.		June.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Adams												
Allen									1			
Blackford						1						
Delaware					4					2	3	1
Gibson	1		3		1	1	1				5	2
Grant												1
Huntington									3		1	1
Jay				1	2	1	2	1		1		2
Marion												
Pike	4		3		5	1	6	1	4	4	6	1
Randolph					2	1			1		7	1
Sullivan	1		1	3	3	5	2	2		3		4
Vanderburg												
Wells								1				
	6		7	4	17	10	11	5	9	10	22	13

County.	July.		Aug.		Sept.		Oct.		Nov.		Dec.		Total.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Adams	1		1		1				1		1	1	5	1
Allen			1						1				3	
Blackford			1										1	1
Delaware	1		1	1			3		4		1	1	17	5
Gibson	1	6		1	1			1	1	4	2		16	15
Grant	1	1			1				1		2		5	2
Huntington	3	2	1	1	3		3		4	1	4	1	22	6
Jay	1	1	1	1					1	1	1	1	8	10
Marion							1						1	
Pike	9	5	1	4	10	4			4	3	1	1	53	24
Randolph			3	1	3		2		1	1	2		21	4
Sullivan	2	2		2	1	2	1			1		2	11	27
Vanderburg								1				1		1
Wells	1		1	2	1		2		1	1			6	4
	20	17	11	13	21	6	12	2	19	12	14	8	160	100

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Wells completed in Indiana, 1914–1918.

Month.	Oil.					Dry.					Total completed.a				
	1914	1915	1916	1917	1918	1914	1915	1916	1917	1917	1914	1915	1916	1917	1918
January	36	5	9	6	6	17	9	6	4	.....	54	14	16	11	6
February	45	10	9	6	7	25	2	7	3	4	71	14	17	11	12
March	42	11	13	14	17	30	3	11	1	10	74	15	26	15	27
April	44	11	9	13	11	27	7	13	7	5	71	18	22	20	18
May	74	7	22	11	9	27	7	14	9	10	104	14	37	21	19
June	79	6	22	15	22	34	8	10	9	13	113	14	32	25	36
July	54	8	15	18	20	26	10	10	11	17	82	19	25	29	37
August	40	2	14	13	11	22	6	7	7	13	63	9	21	22	25
September	23	5	15	14	21	20	12	5	6	6	43	19	21	20	29
October	10	6	16	29	12	7	6	2	10	2	18	12	18	39	14
November	8	10	9	20	19	11	13	8	8	12	21	23	18	30	32
December	15	17	7	15	14	13	3	5	8	8	28	21	13	23	22
	470	98	160	174	169	259	86	98	83	100	742	192	266	266	277

a Including gas wells.

Initial daily production of new wells completed in Indiana in 1918, in barrels.

County.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Adams	.....	.....	.....	.....	.....	.....	8	10	4	.....	10	5	37
Allen	.....	.....	.....	.....	4	.....	.....	3	.....	.....	70	.....	77
Blackford	.....	.....	.....	.....	.....	.....	.....	5	.....	.....	.....	.....	5
Delaware	.....	.....	145	.....	.....	8	40	100	.....	380	214	2	889
Gibson	20	160	75	20	.....	67	2	.....	26	.....	60	60	490
Grant	.....	.....	.....	.....	.....	.....	5	.....	4	.....	2	10	21
Huntington	.....	.....	.....	.....	9	5	85	15	160	70	83	130	557
Jay	.....	.....	20	85	.....	.....	5	5	.....	.....	5	25	145
Marion	.....	.....	.....	.....	.....	.....	.....	.....	.....	20	.....	.....	20
Pike	30	175	135	295	266	365	239	80	157	.....	240	15	1,997
Randolph	.....	.....	60	.....	25	19	.....	11	12	35	5	4	171
Sullivan	10	5	32	6	.....	.....	43	.....	3	1	.....	.....	100
Wells	.....	.....	.....	.....	.....	.....	20	5	10	20	4	.....	59
	60	340	467	406	304	464	447	234	376	526	693	251	4,568

Total and average daily initial production of new wells in Indiana. 1914–1918, by counties, in barrels.

County.	Total initial production.					Average per well.				
	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918
Adams	43	.....	.....	.....	37	10.8	.....	.....	.....	7.4
Allen	.....	.....	.....	289	77	.....	.....	.....	36.1	25.7
Blackford	3	.....	35	5	5	3.0	.....	11.7	5.0	5.0
Daviess	.....	15	30	.....	.....	.....	15.0	15.0	.....	.....
Delaware	545	5	5	75	889	22.7	5.0	5.0	75.0	52.3
Gibson	9	28	155	1,051	490	3.0	7.0	11.1	50.0	30.6
Grant	27	.....	28	7	21	9.0	.....	7.7	2.3	4.2
Harrison	10	.....	.....	.....	.....	5.0	.....	.....	.....	.....
Huntington	.....	.....	.....	.....	557	.....	.....	.....	.....	25.3
Jay	167	4	145	578	145	11.9	4.0	72.5	34.0	18.1
Knox	.....	1	.....	135	.....	.....	1.0	.....	67.5	.....
Marion	.....	.....	.....	.....	20	.....	.....	.....	.....	20.0
Miami	.....	.....	87	116	.....	.....	.....	14.5	9.8	.....
Pike	136	204	872	1,671	1,997	22.7	22.7	22.9	22.3	37.7
Randolph	80	2	150	20	171	20.0	2.0	150.0	20.0	8.1
Shelby	50	10	.....	.....	.....	12.5	10.0	.....	.....	.....
Spencer	.....	.....	4	.....	.....	.....	.....	4.0	.....	.....
Sullivan	7,294	1,750	1,862	967	100	18.2	26.5	23.6	39.3	9.1
Vigo	50	545	168	.....	.....	16.7	41.9	21.0	.....	.....
Wabash	20	.....	.....	.....	.....	20.0	.....	.....	.....	.....
Wells	2	.....	18	.....	59	20.0	.....	9.0	.....	9.8
	8,436	2,564	3,554	4,914	4,568	18.0	26.2	22.2	28.2	27.0

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Total daily initial production of new wells in Indiana, 1914–1918, by months, in barrels.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.	Monthly average.
1914.....	677	1,213	1,130	1,100	977	1,257	811	410	272	154	151	284	8,436	703
1915.....	62	115	151	170	137	225	128	15	129	327	443	662	2,564	214
1916.....	296	182	292	148	488	524	282	217	536	271	205	113	3,554	296
1917.....	173	106	281	303	432	546	493	344	453	762	430	591	4,914	410
1918.....	60	340	467	406	304	464	447	234	376	526	693	251	4,568	381

ILLINOIS OIL FIELD.

GENERAL STATEMENT.

The Illinois field lies wholly within the State of Illinois and includes the principal area of production of oil along the La Salle anticline in southeastern Illinois as well as a number of scattered pools of small individual extent in the central and western parts of the State. The oil in this field ranges in gravity from 28° to 40° Baumé and contains varying proportions of both asphalt and paraffin, and is obtained for the most part from sandstone and limestone layers in formations belonging to the Pennsylvanian and Mississippian series of the Carboniferous system. The productive pools on the La Salle anticline occur chiefly on the eastern flank of this arch which is asymmetrical, the western limb being much more steeply inclined than the eastern. The general oil-bearing territory extends in a slightly southeast direction from the vicinity of Westfield in northwestern Clark County through Clark and Crawford counties to the vicinity of Allendale in Wabash County. There are outliers or extensions in Coles, Cumberland, and Jasper counties, but the three counties first named have produced by far the greater portion of the oil.

Development in eastern Illinois began with a well drilled near Casey, in Clark County, which produced about 35 barrels a day from a sand found at a depth of less than 400 feet. This was in 1904, and by the end of 1905 more than a thousand barrels a day were being marketed. The maximum output of nearly 34,000,000 barrels was in 1908. Since 1910 the production has declined at an average rate of 10 per cent a year.

The production of petroleum in 1918—13,365,974 barrels—was less by 2,410,886 barrels, or 15 per cent, than the output in 1917. This very marked decrease in production was coincident with a very marked decrease in the number of new wells drilled, and a corresponding general increase in the proportion of dry holes.

The price of Illinois crude at the wells which in 1917 showed an increase from $1.62 to $2.12 a barrel continued to increase throughout the first half of 1918 to the record high price of $2.42 a barrel on July 9. This price has been maintained since that date.

Stocks of Illinois oil continued to decrease, reaching a low level of 2,366,752 barrels at the end of the year, as compared with 3,560,222 at the end of 1917 and with 6,599,972 at the end of 1916.

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DEVELOPMENT.

Field activity in 1918 was less than in any year since the State began to assume importance in the petroleum industry. Only 396 new wells were completed in 1918, compared with 646 in 1917 and 1,461 in 1916. At the same time there was a marked increase in the percentage of dry holes, which amounted to 27 per cent of the total number completed in 1918, as compared with 23 per cent in 1917 and 22 per cent in 1916. The average initial yield of the 279 oil wells completed was 21 barrels. Productive oil wells were completed in nine counties and failures were reported from three, although the greater part of the drilling was in the old pools along the La Salle anticline in the southeastern part of the State. In the "shallow sand" area on this anticline only 82 wells were completed—less than half the number completed in 1917. Moreover, the percentage of dry holes rose from 14 per cent in 1916 and 1917 to 18 per cent in 1918. Most of the wells were drilled in the territory in Clark County, but this county showed a decline in average initial daily production from 12.4 to 9.3 barrels. The largest well reported from this "shallow sand" territory was the Ohio Oil Co.'s No. 1, on the Lee tract, Clark County, with an initial production of 108 barrels. In the "deep sand" area of Crawford, Lawrence, and Wabash counties 290 wells were completed, as against 437 in 1917, and of these 29 per cent were dry holes, as compared with 24 per cent in 1917. Crawford County was most active with 136 oil wells having an average initial daily production of 18.1 barrels, the highest average since 1913. Nine wells in Lawrence County and 10 in Crawford County are reported to have had an initial production of 100 barrels or more, the largest being 200 barrels from the Ohio Oil Co.'s No. 31, on the Ryan tract, Lawrence County. In the Carlyle pool in Clinton County in southern central Illinois nine wells were completed, four of which were oil wells with an average initial production of 8.7 barrels, four were dry holes, and one was a gas well. Two wells were drilled in Marion County to the east and two in Washington County, south of Clinton, all of which were dry holes. In McDonough County in western Illinois 11 wells were drilled, which were oil wells having an average initial production of 5.7 barrels.

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PETROLEUM PRODUCED.

Petroleum produced in Illinois, 1889–1918.

Year.	Quantity (barrels).	Percentage of total production of United States.	Increase or decrease.		Value.	Yearly average price per barrel.
			Barrels.	Per cent.		
1889	1,460				$4,906	$3.360
1890	900		− 560	− 38.36	3,000	3.333
1891	675		− 225	− 25.00	2,363	3.500
1892	521		− 154	− 22.81	1,823	3.500
1893	400		− 121	− 23.22	1,400	3.500
1894	300		− 100	− 25.00	1,800	6.000
1895	200		− 100	− 33.33	1,200	6.000
1896	250		+ 50	+ 25.00	1,250	5.000
1897	500		+ 250	+ 100.00	2,000	4.000
1898	360		− 140	− 28.00	1,800	5.000
1899	360				1,800	5.000
1900	200		− 160	− 44.44	1,000	5.000
1901	250		+ 50	+ 25.00	1,250	5.000
1902	200		− 50	− 20.00	1,000	5.000
1903			− 200	− 100.00		
1904						
1905	181,084	0.13	+ 181,084		116,561	.644
1906	4,397,050	3.47	+ 4,215,966	+ 2,328.18	3,274,818	.745
1907	24,281,973	14.62	+ 19,884,923	+ 452.23	16,432,947	.677
1908	33,686,238	18.87	+ 9,404,265	+ 38.73	22,649,561	.672
1909	30,898,339	16.87	− 2,787,899	− 8.28	19,788,864	.640
1910	33,143,362	15.82	+ 2,244,923	+ 7.27	19,669,383	.593
1911	31,317,638	14.21	− 1,826,224	− 5.51	19,734,339	.639
1912	28,601,308	12.83	− 2,715,730	− 8.67	24,332,605	.851
1913	23,893,899	9.62	− 4,707,409	− 16.45	30,971,910	1.296
1914	21,919,749	8.25	− 1,974,150	− 8.26	25,426,179	1.160
1915	19,041,695	6.77	− 2,878,054	− 13.13	18,655,550	.980
1916	17,714,235	5.89	− 1,327,460	− 6.97	29,237,168	1.650
1917	15,776,860	4.71	− 1,937,375	− 10.94	31,358,069	1.988
1918	13,365,974	3.76	− 2,410,886	− 15.28	31,230,000	2.337
	298,225,380	6.47			292,904,846	.982

Petroleum produced in Illinois, 1914–1918, in barrels.

Month.	1914	1915	1916	1917	1918
January	1,935,492	1,614,026	1,373,615	1,433,901	1,004,462
February	1,570,790	1,542,383	1,330,016	1,197,218	1,031,472
March	1,969,915	1,761,099	1,552,827	1,433,513	1,215,240
April	1,833,099	1,643,479	1,376,454	1,308,431	1,145,106
May	1,970,688	1,638,733	1,572,217	1,424,684	1,216,235
June	1,932,303	1,603,733	1,527,589	1,336,263	1,125,684
July	1,907,521	1,636,932	1,540,887	1,369,464	1,193,233
August	1,844,983	1,593,436	1,561,066	1,365,871	1,127,151
September	1,817,437	1,535,040	1,467,892	1,264,595	1,089,608
October	1,813,364	1,533,972	1,522,930	1,306,136	1,139,493
November	1,678,783	1,452,285	1,454,302	1,246,410	1,018,577
December	1,645,374	1,486,577	1,414,440	1,090,374	1,059,713
	21,919,749	19,041,695	17,714,235	15,776,860	13,365,974

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Average daily output of petroleum in Illinois, 1914–1918, in barrels.

Month.	1914	1915	1916	1917	1918
January	62,435	52,065	44,310	46,255	32,402
February	56,100	55,085	45,863	42,758	36,838
March	63,546	56,810	50,091	46,242	39,201
April	61,103	54,783	46,548	43,614	38,170
May	63,570	52,862	50,717	45,956	39,233
June	64,410	53,458	50,920	45,421	37,523
July	61,533	52,804	49,706	44,176	38,491
August	59,516	51,401	50,357	44,060	36,360
September	60,581	51,168	48,930	42,152	36,320
October	58,496	49,483	49,127	42,133	36,758
November	55,959	48,410	48,477	41,547	33,953
December	53,076	47,954	45,627	35,173	34,184
Average	60,054	52,169	48,400	43,291	36,619

PIPE-LINE RUNS, DELIVERIES, AND STOCKS.

Pipe-line runs and deliveries to trade of petroleum from Illinois and stocks at end of each month in 1917 and 1918, in barrels.

Month.	1917			1918		
	Runs.	Deliveries.	Stocks.	Runs.	Deliveries.	Stocks.
Dec. 31, 1916			6,599,972			
January	1,433,901	1,752,485	6,281,388	1,004,462	988,043	3,576,641
February	1,197,218	1,549,933	5,928,673	1,031,472	1,041,786	3,566,327
March	1,433,513	1,905,255	5,456,931	1,215,240	1,355,840	3,425,727
April	1,308,431	1,627,553	5,137,809	1,145,106	1,373,489	3,197,344
May	1,424,684	1,705,252	4,857,241	1,216,235	1,049,297	3,364,282
June	1,336,263	1,602,950	4,590,554	1,125,684	1,093,933	3,396,033
July	1,369,464	1,663,765	4,296,253	1,193,233	1,355,173	3,234,093
August	1,365,871	1,538,078	4,124,046	1,127,151	1,248,660	3,112,584
September	1,264,595	1,164,478	4,224,163	1,089,608	1,353,172	2,849,020
October	1,306,136	1,370,148	4,160,151	1,139,493	1,299,242	2,689,231
November	1,246,410	1,258,380	4,148,181	1,018,577	1,225,421	2,482,387
December	1,090,374	1,678,333	3,560,222	1,059,713	1,175,348	2,366,752
	15,776,860	18,816,610		13,365,974	14,559,444	

Pipe-line runs, deliveries, and stocks of the Ohio Oil Co. in 1914 and the Illinois Pipe Line Co. in 1915–1918 in Illinois, in barrels.

Pipe-line runs.

Month.	1914	1915	1916	1917	1918
January	1,425,574	1,183,446	936,570	965,686	677,805
February	1,148,926	1,119,973	885,070	808,350	684,012
March	1,469,331	1,208,446	1,056,212	965,605	802,979
April	1,328,430	1,159,393	933,335	870,855	747,902
May	1,434,303	1,155,255	1,057,769	956,166	801,093
June	1,407,706	1,134,519	1,043,541	892,989	749,029
July	1,398,949	1,144,094	1,044,236	911,342	781,941
August	1,371,731	1,112,979	1,071,959	903,183	731,602
September	1,345,016	1,077,996	1,001,549	836,609	705,844
October	1,350,167	1,078,114	1,025,055	856,325	738,996
November	1,246,292	1,013,783	976,503	813,024	662,878
December	1,222,575	1,016,719	954,199	721,857	687,673
	16,148,900	13,464,717	11,985,998	10,501,991	8,771,754

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Pipe-line runs, deliveries, and stocks of the Ohio Oil Co. in 1914 and the Illinois Pipe Line Co. in 1915–1918 in Illinois, in barrels—Continued.

Deliveries.[a]

Month.	1914	1915	1916	1917	1918
January	936,867	31,910	25,140	26,597	64,923
February	1,027,023	26,809	24,406	27,389	3,765
March	749,703	24,703	22,729	35,659	74,335
April	525,769	23,681	16,768	13,616	127,902
May	819,105	30,611	106,715	12,982	108,782
June	752,134	16,192	34,618	4,649	75,350
July	803,558	15,907	26,437	5,393	70,314
August	474,569	21,252	38,247	11,076	109,115
September	594,960	36,565	21,142	7,663	48,175
October	630,028	29,727	8,928	162,871	123,918
November	256,567	16,551	13,346	160,090	71,460
December	15,090	14,319	20,889	176,627	105,443
	7,585,373	288,227	359,365	644,612	983,492

Stocks.[b]

January	5,508,791	3,351,079	4,588,350	2,149,064	1,982,892
February	5,188,339	3,689,625	4,388,169	2,254,353	1,929,769
March	5,627,743	4,460,698	4,275,128	2,167,508	2,024,858
April	6,500,409	5,177,985	3,968,456	2,487,244	2,133,659
May	7,284,952	5,625,562	3,709,265	2,697,491	2,244,220
June	8,035,086	5,763,894	3,500,393	2,486,708	2,203,773
July	8,682,851	4,990,447	2,043,284	2,225,075	2,113,578
August	9,683,090	5,165,511	2,001,292	2,401,052	1,866,285
September	10,473,407	5,083,656	2,191,174	2,389,088	1,846,613
October	11,033,448	4,979,712	2,163,016	2,436,225	1,653,252
November	11,183,664	4,799,585	2,264,739	2,345,844	1,618,430
December	11,390,608	4,611,579	2,098,910	2,195,740	1,578,198

[a] These deliveries are to trade only. Deliveries to other pipe lines are also made.
[b] Stocks include some Indiana petroleum of Illinois grade.

PRICES.

Prices per barrel of Illinois petroleum in 1916–1918.

1916			1917			1918		
Date.	Illinois.	Plymouth.	Date.	Illinois.	Plymouth.	Date.	Illinois.	Plymouth.
Jan. 1	$1.47	$1.33	Jan. 1	$1.62	$1.53	Jan. 1	$2.12	$2.08
Jan. 3	1.57	.....	Jan. 2	1.72	.....	Feb. 9	2.22	2.13
Jan. 21	.....	1.38	Jan. 4	.....	1.63	Mar. 21	2.32	2.33
Jan. 27	1.62	1.43	Jan. 8	1.82	1.73	July 9	2.42	.....
Feb. 16	1.72	.....	Jan. 13	.....	1.83			
Mar. 6	.....	1.53	Jan. 30	1.87	.....			
Mar. 13	.....	1.58	Apr. 16	1.92	.....			
Mar. 16	1.82	1.68	Aug. 16	2.12				
July 28	1.72	1.58						
Aug. 1	1.62	1.48						
Aug. 3	.....	1.38						
Aug. 4	1.52	.....						
Aug. 14	1.47	1.18						
Aug. 17	.....	1.08						
Aug. 28	.....	1.03						
Nov. 18	1.52	.....						
Nov. 30	.....	1.13						
Dec. 13	1.57	1.23						
Dec. 19	1.62	1.33						
Dec. 28	.....	1.43						
Dec. 29	.....	1.53						

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Average monthly prices per barrel of Illinois petroleum, 1915–1918.

Month.	1915		1916		1917		1918	
	Illinois.	Plymouth.	Illinois.	Plymouth.	Illinois.	Plymouth.	Illinois.	Plymouth.
January	$0.89	.....	$1.57	$1.36	$1.79	$1.76	$2.12	$2.03
February	.87	.....	1.67	1.43	1.87	1.83	2.19	2.09
March	.84	.....	1.77	1.60	1.87	1.83	2.26	2.20
April	.84	.....	1.82	1.68	1.90	1.83	2.32	2.33
May	.84	.....	1.82	1.68	1.92	1.83	2.32	2.33
June	.84	.....	1.82	1.68	1.92	1.83	2.32	2.33
July	.84	.....	1.81	1.67	1.92	1.83	2.39	2.33
August	.90	$0.58	1.50	1.22	2.02	1.93	2.42	2.33
September	1.07	.76	1.47	1.03	2.12	2.03	2.42	2.33
October	1.19	.93	1.47	1.03	2.12	2.03	2.42	2.33
November	1.32	1.03	1.49	1.03	2.12	2.03	2.42	2.33
December	1.44	1.24	1.57	1.26	2.12	2.03	2.42	2.33
Average	.99	.91	1.65	1.39	1.97	1.90	2.34	2.28

SUMMARY OF WELLS DRILLED.

The statistics of field operations presented in the following tables are compiled from trade-journal sources and differ somewhat from those on page 987, which are obtained from reports received directly from the oil producers.

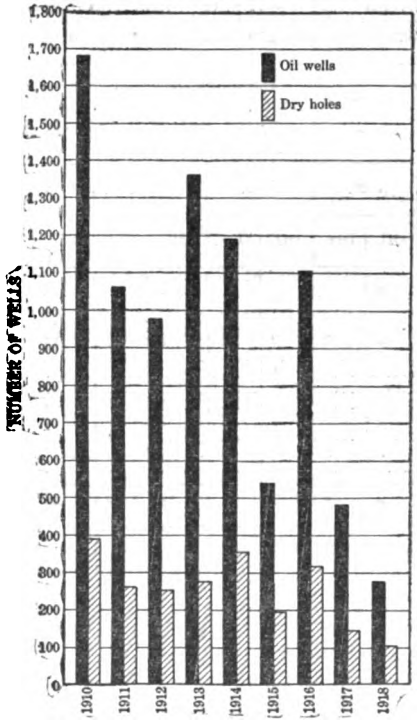

FIGURE 106.—Comparison of number of producing oil wells with dry holes drilled in the Illinois field, 1910–1918.

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Wells completed in Illinois, 1914–1918.

County.	Oil.					Dry.					Total completed.[a]				
	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918
Adams							2					2			
Bond						2		2			2		2		
Brown								2					2		
Champaign							2					2			
Clark	157	107	218	116	60	62	33	34	21	11	221	141	256	137	71
Clinton	2		11	1	4	2	2	23	8	4	4	2	34	9	9
Coles	16	2	6			5	1	5	1	3	21	3	11	1	5
Crawford	542	153	391	199	136	136	54	152	70	59	706	215	569	276	201
Cumberland	22	37	34	25	1	2	4	3	1		24	44	40	26	1
Edgar		3		4	2		1					4		4	2
Edwards							1					1			
Fayette								1					1		
Hancock	1		12	4		19	8	10	1		20	8	22	5	
Henderson			2					1					3		
Jackson							1	1				1	1		
Jasper	3				2	2				1	5				3
Lawrence	294	128	212	113	58	69	28	34	19	13	365	157	246	123	71
McDonough	138	97	186	14	11	36	33	25	4		174	130	211	18	11
Macoupin	3	1				2	3	3			5	10	6		
Madison						1	1				1	1			
Marion	6	6	18			1		8	5	2	7	6	26	6	2
Montgomery							3					3			
Perry									1					1	
Randolph							1					1			
St. Clair							2					2			
Saline						1		1	2		1		1	2	
Schuyler							17	1				17	1		
Wabash	7	5	17	12	5	5	1	12	16	13	12	6	29	28	18
Washington							1			2		1			2
Miscellaneous						11					11				
	1,191	539	1,107	488	279	356	199	318	149	108	1,579	757	1,461	646	396

[a] Including gas wells.

Oil wells and dry holes drilled in Illinois in 1918.

County.	Jan.		Feb.		Mar.		Apr.		May.		June.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Clark	3				4		6	1	4	2	9	3
Clinton							1	1			1	
Coles												1
Crawford	2	2	2		8	4	13	4	12	4	15	4
Cumberland												
Edgar			1		1							
Jasper					1					1	1	
Lawrence	2				3	1	5	2	3		4	
McDonough	1				1		1				2	
Marion						1						
Wabash	1	1		1		3		3	1			
Washington												1
	9	3	3	1	18	9	26	11	20	7	32	9

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Oil wells and dry holes drilled in Illinois in 1918—Continued.

County.	July.		Aug.		Sept.		Oct.		Nov.		Dec.		Total.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Clark	5	3	7	.....	2	2	4	.....	7	.....	9	.....	60	11
Clinton	.....	2	.....	.....	2	.....	.....	.....	.....	.....	.....	1	4	4
Coles	.....	1	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	3
Crawford	13	3	19	13	13	5	10	2	14	9	15	9	136	59
Cumberland	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	1	.....
Edgar	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2	.....
Jasper	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2	1
Lawrence	9	3	5	2	10	.....	3	2	7	2	7	1	58	13
McDonough	3	.....	.....	.....	.....	.....	3	.....	.....	.....	.....	.....	11	.....
Marion	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	2
Wabash	2	1	1	.....	.....	2	.....	1	.....	1	.....	.....	5	13
Washington	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	2
	32	13	32	17	27	10	20	5	29	12	31	11	279	108

Wells completed in Illinois, 1914–1918.

Month.	Oil.					Dry.					Total completed.[a]				
	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918
January	126	31	60	52	9	15	14	27	14	3	148	47	94	66	13
February	103	22	58	29	3	28	13	18	16	1	135	37	82	46	5
March	116	40	87	27	18	18	12	28	13	9	136	53	119	40	27
April	148	43	71	40	26	41	10	21	12	11	191	54	93	54	38
May	116	33	128	49	20	35	18	37	13	7	154	52	169	64	30
June	123	36	141	50	32	52	16	37	10	9	180	54	184	60	41
July	98	47	116	54	32	37	16	26	18	13	138	64	143	73	46
August	98	51	124	58	32	39	19	30	15	17	140	71	156	73	49
September	111	49	113	36	27	28	16	28	9	10	139	66	142	47	38
October	69	56	70	39	20	27	19	30	8	5	98	79	103	48	25
November	48	58	86	31	29	14	25	23	10	12	63	84	110	41	42
December	35	73	53	23	31	22	21	13	11	11	57	96	66	34	42
	1,191	539	1,107	488	279	356	199	318	149	108	1,579	757	1,461	646	369

[a] Including gas wells.

Initial daily production of new wells completed in Illinois in 1918, in barrels.

County.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Clark	95	.....	17	72	19	103	34	78	21	20	54	47	560
Clinton	.....	.....	.....	3	.....	2	.....	.....	30	.....	.....	.....	35
Crawford	18	6	108	84	195	247	277	399	437	283	201	205	2,460
Cumberland	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	1
Edgar	.....	5	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	6
Jasper	.....	.....	2	.....	.....	3	.....	.....	.....	.....	.....	.....	5
Lawrence	80	.....	170	216	235	105	565	198	462	43	219	308	2,601
McDonough	5	.....	10	3	.....	10	12	.....	.....	23	.....	.....	63
Wabash	50	.....	.....	.....	5	.....	90	1	.....	.....	.....	.....	146
	248	11	308	378	454	470	978	676	950	369	475	560	5,877

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Total and average initial daily production of new wells in Illinois, 1914–1918, in barrels.

County.	Total initial production.					Average per well.				
	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918
Clark	1,590	2,014	3,737	1,439	560	10.1	18.8	17.1	12.4	9.3
Clinton	20	.....	291	10	35	10.0	.....	26.5	10.0	8.7
Coles	172	35	57	.....	.....	10.7	17.5	9.5	.....	.....
Crawford	8,613	1,776	6,076	3,093	2,460	15.9	11.6	15.5	15.5	13.1
Cumberland	127	810	434	148	1	5.8	21.9	12.8	5.9	1.0
Edgar	.....	6	.....	25	6	.....	2.0	.....	6.3	3.0
Hancock	45	.....	167	30	.....	45.0	.....	13.9	7.5	.....
Henderson	.....	.....	7	.....	.....	.....	.....	3.5	.....	.....
Jasper	28	.....	.....	.....	5	9.3	.....	.....	.....	2.5
Lawrence	24,324	6,329	9,540	4,297	2,601	82.7	49.4	45.0	38.0	44.8
McDonough	3,919	2,592	1,948	46	63	28.4	26.7	10.5	3.3	5.7
Macoupin	15	5	.....	.....	.....	5.0	5.0	.....	.....	.....
Marion	70	270	207	.....	.....	11.6	45.0	11.5	.....	.....
Wabash	345	328	2,325	1,040	146	49.3	65.6	136.8	86.7	29.2
	39,268	14,165	24,789	10,128	5,877	33.0	26.3	22.4	20.8	21.1

Total initial daily production of new wells in Illinois, 1914–1918, by months, in barrels.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.	Monthly average.
1914	2,925	3,415	2,443	4,838	5,552	6,542	3,801	2,792	2,925	1,517	1,156	1,362	39,268	3,272
1915	975	640	1,478	1,254	953	1,219	1,366	1,367	1,236	1,263	1,151	1,263	14,165	1,180
1916	984	1,105	2,374	1,056	2,686	2,828	2,647	2,957	2,700	1,962	2,478	1,112	24,789	2,066
1917	1,165	790	360	694	1,020	1,161	875	1,437	1,091	672	509	354	10,128	844
1918	248	11	308	378	454	470	978	676	950	369	475	560	5,877	490

MID-CONTINENT OIL FIELD.

GENERAL STATEMENT.

For commercial purposes it is customary to group under the title "Mid-Continent field" the areas of oil production in Kansas, Oklahoma, northern and central Texas, and northern Louisiana.[1] In Kansas, Oklahoma, and northern Texas petroleum is derived mainly from sandstone layers included in formations of the Pennsylvanian series (upper Carboniferous). In southern Oklahoma sandstone layers in the "Red Beds" of the Permian series (latest Carboniferous) form the reservoirs of oil in the Healdton district. In northern Louisiana and central Texas the oil is found in sandstones or other porous rocks belonging to the Cretaceous and Tertiary systems. The occurrence of oil throughout the Mid-Continent field is in anticlines, domes, half domes, and terraces on the flanks of major uplifts, such as the Ozark, Wichita, Arbuckle, and Sabine uplifts.

[1] Some statistics for the Texas and Louisiana portions of the Mid-Continent field are given in the sections on those States under the heading "Gulf oil field" (pp. 1076–1106).

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PETROLEUM PRODUCED.

Petroleum produced in the Mid-Continent field in 1917 and 1918, in barrels.

Month.	Kansas.	Oklahoma.	Northern and Central Texas.	Northern Louisiana.	Total.
1917.					
January	2,199,862	8,564,301	813,713	727,487	12,305,363
February	1,739,952	7,929,890	738,544	612,041	11,020,427
March	2,498,789	9,474,878	825,506	738,149	13,537,322
April	2,323,291	8,938,605	813,207	744,428	12,819,531
May	2,366,411	8,963,599	868,594	817,431	13,016,035
June	2,681,568	8,995,842	885,933	812,464	13,375,807
July	3,009,914	9,563,613	938,462	854,925	14,366,914
August	3,610,946	9,041,907	1,007,676	847,807	14,508,336
September	4,101,561	9,012,971	995,499	814,907	14,924,938
October	4,116,002	9,560,032	1,002,886	819,799	15,498,719
November	4,304,013	9,143,094	998,429	280,108	14,725,644
December	3,583,816	8,318,739	1,012,197	492,417	13,407,169
	36,536,125	107,507,471	10,900,646	8,561,963	163,506,205
1918.					
January	3,855,322	8,048,966	1,033,895	570,056	13,508,239
February	3,404,699	7,768,787	931,856	627,683	12,733,025
March	4,070,370	8,953,389	1,012,361	807,748	14,843,868
April	4,238,706	8,098,833	1,039,313	996,884	14,373,736
May	4,089,150	8,740,788	1,078,638	1,154,057	15,062,633
June	4,113,295	8,521,536	1,114,203	1,051,946	14,800,980
July	4,490,257	9,128,313	1,348,990	1,308,851	16,276,411
August	4,174,275	8,460,355	1,572,023	1,271,148	15,477,801
September	4,042,394	8,725,095	1,643,762	1,373,457	15,784,708
October	3,529,384	9,106,068	1,754,180	1,471,384	15,863,016
November	2,955,341	9,141,404	2,048,823	1,369,214	15,514,782
December	2,487,824	8,651,536	2,702,568	1,301,971	15,143,899
	45,451,017	103,347,070	17,280,612	13,304,399	179,383,098
Increase or decrease:					
Barrels	+8,914,892	−4,160,401	+6,379,966	+4,742,436	+15,876,893
Per cent	+24.40	−3.87	+58.53	+55.39	+9.71

Petroleum produced in the Mid-Continent field, 1889–1918.

Year.	Quantity (barrels).	Percentage of total production of U. S.	Increase or decrease.		Value.	Yearly average price per barrel.
			Barrels.	Per cent.		
1889	500	.....	.....	.....	$2,500	$5.000
1890	1,200	.....	+ 700	+140.00	8,400	7.000
1891	1,430	.....	+ 230	+ 19.17	9,950	6.958
1892	5,080	.....	+ 3,650	+255.24	5,480	1.079
1893	18,010	0.04	+ 12,930	+254.53	18,060	1.003
1894	40,130	.08	+ 22,120	+122.82	40,810	1.017
1895	44,467	.08	+ 4,337	+ 10.81	26,910	.605
1896	115,141	.19	+ 70,674	+158.93	52,587	.457
1897	147,648	.24	+ 32,507	+ 28.23	71,914	.487
1898	616,600	1.11	+ 468,952	+317.62	305,875	.496
1899	738,183	1.29	+ 121,583	+ 19.72	523,068	.709
1900	917,225	1.44	+ 179,042	+ 24.25	945,992	1.031
1901	989,696	1.43	+ 72,471	+ 7.90	778,097	.787
1902	986,720	1.12	− 2,976	− .30	745,803	.756
1903	1,573,085	1.57	+ 586,365	+ 59.42	1,645,936	1.046
1904	6,186,629	5.28	+ 4,613,544	+293.28	5,859,982	.947
1905	12,533,777	9.30	+ 6,347,148	+102.60	6,908,002	.551
1906	22,839,911	18.05	+10,306,134	+ 82.23	10,357,923	.454
1907	46,896,267	28.23	+24,056,356	+105.33	19,239,085	.410
1908	48,823,747	27.35	+ 1,927,480	+ 4.11	19,134,658	.392
1909	50,833,740	27.75	+ 2,009,993	+ 4.12	18,863,436	.371
1910	59,217,582	28.26	+ 8,383,842	+ 16.49	23,163,676	.391
1911	66,595,477	30.21	+ 7,377,895	+ 12.46	31,928,208	.479
1912	65,473,323	29.48	− 1,122,154	− 1.68	45,300,658	.692
1913	84,920,225	34.18	+19,446,902	+ 29.70	80,767,758	.951
1914	[a] 97,994,900	36.87	+13,074,675	+ 15.40	78,671,402	.803
1915	123,294,317	43.86	+25,299,417	+ 25.82	72,431,301	.587
1916	136,934,439	45.528	+13,640,122	+ 11.06	162,816,998	1.189
1917	163,506,205	48.761	+26,571,766	+ 19.40	282,796,124	1.730
1918	179,383,098	50.40	+15,876,893	+ 9.71	393,031,158	2.191
	1,171,628,752	25.43	.....	.....	1,256,451,751	1.072

[a] Does not include 19,550,000 barrels produced in 1914 in the Cushing and Healdton fields in Oklahoma and placed in field storage.

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Petroleum produced, value, and average price per barrel in the Mid-Continent field, 1909–1918, by States.

Year.	Kansas and Oklahoma.			Northern and central Texas.		
	Quantity (barrels).	Value.	Average price per barrel.	Quantity (barrels).	Value.	Average price per barrel.
1909	49,122,982	$17,920,623	$0.364	681,940	$393,732	$0.577
1910	53,157,386	20,367,423	.383	969,403	505,396	.521
1911	57,348,456	27,060,523	.472	2,251,198	1,213,960	.539
1912	53,019,867	35,768,302	.674	5,275,507	4,112,815	.779
1913	65,954,413	61,830,231	.937	9,184,252	9,125,185	.992
1914	[a] 76,735,309	59,686,261	.778	9,451,122	7,778,455	.823
1915	100,738,730	58,409,024	.580	7,473,553	4,656,934	.623
1916	115,809,792	138,803,763	1.199	9,303,005	11,834,973	1.272
1917	144,043,596	248,767,554	1.727	10,900,646	19,952,665	1.830
1918	148,798,087	331,682,407	2.229	17,280,612	38,313,019	2.217

Year.	Northern Louisiana.			Total.		
	Quantity (barrels).	Value.	Average price per barrel.	Quantity (barrels).	Value.	Average price per barrel.
1909	1,028,818	$549,081	$0.533	50,833,740	$18,863,436	$0.371
1910	5,090,793	2,290,857	.450	59,217,582	23,163,676	.391
1911	6,995,828	3,653,725	.522	66,595,477	31,928,208	.479
1912	7,177,949	5,419,541	.755	65,473,323	45,300,658	.692
1913	9,781,560	9,812,342	1.003	84,920,225	80,767,758	.951
1914	11,808,469	11,206,686	.949	97,994,900	78,671,402	.803
1915	15,082,084	9,365,343	.621	123,294,317	72,431,301	.587
1916	11,821,642	12,178,262	1.030	136,934,439	162,816,998	1.189
1917	8,561,963	14,075,905	1.644	163,506,205	282,796,124	1.730
1918	13,304,399	23,035,732	1.731	179,383,098	393,031,158	2.191

[a] Does not include 19,550,000 barrels produced in 1914 in the Cushing and Healdton fields in Oklahoma and placed in field storage.

Petroleum produced in the Mid-Continent field, 1914–1918, in barrels.

Month.	1914	1915	1916	1917	1918
January	8,040,953	8,056,449	10,400,281	12,305,363	13,508,239
February	7,246,281	8,238,063	10,725,449	11,020,427	12,733,025
March	9,226,674	9,347,522	11,813,497	13,537,322	14,843,868
April	8,593,220	13,305,713	10,846,592	12,819,581	14,373,736
May	9,161,882	9,959,638	11,901,287	13,016,035	15,062,633
June	9,081,698	10,496,652	11,781,430	13,375,807	14,800,980
July	8,872,958	11,502,482	11,342,743	14,366,914	16,276,411
August	6,837,976	10,488,861	10,932,234	14,508,386	15,477,801
September	6,274,684	10,303,130	11,401,009	14,924,988	15,784,708
October	7,901,411	10,032,685	12,377,420	15,498,719	15,863,016
November	8,193,609	10,017,997	11,586,837	14,725,644	15,514,782
December	8,563,554	11,515,125	11,825,660	13,407,169	15,143,899
	97,994,900	123,294,317	136,934,439	163,506,205	179,383,098

Average daily production of petroleum in the Mid-Continent field, 1914–1918, in barrels.

Month.	1914	1915	1916	1917	1918
January	259,386	259,886	335,493	396,947	435,750
February	258,796	294,216	369,843	393,587	454,751
March	297,635	301,533	381,081	436,688	478,834
April	286,440	443,523	361,553	427,318	479,125
May	295,545	321,279	383,912	419,872	485,891
June	302,724	349,889	392,714	445,860	493,366
July	286,225	371,048	365,895	463,449	525,045
August	220,580	338,351	352,653	468,021	499,284
September	209,156	343,437	380,034	497,498	526,157
October	254,885	323,635	399,272	499,959	511,710
November	273,120	333,934	386,228	490,855	517,159
December	276,243	372,424	381,473	432,489	488,513
Average	268,479	337,793	374,138	447,711	491,461

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PIPE-LINE RUNS, DELIVERIES, AND STOCKS.

Pipe-line runs and deliveries to trade of petroleum from the Mid-Continent field and stocks at end of each month in 1917 and 1918, in barrels.

Month.	1917			1918		
	Runs.	Deliveries.	Stocks.	Runs.	Deliveries.	Stocks.
Dec. 31, 1916			100,400,966			
January	12,305,363	9,234,757	103,471,572	13,508,239	13,801,811	99,132,851
February	11,020,427	10,386,550	104,105,449	12,733,025	14,454,991	97,410,885
March	13,537,322	13,166,588	104,476,183	14,843,868	15,708,275	96,546,478
April	12,819,531	12,132,798	105,162,916	14,373,736	14,922,072	95,998,142
May	13,016,035	13,192,540	104,986,411	15,062,633	17,929,258	93,131,517
June	13,375,807	11,914,779	106,447,439	14,800,980	12,631,719	95,300,778
July	14,366,914	13,042,042	107,772,311	16,276,411	18,939,770	92,637,419
August	14,508,336	15,359,379	106,921,268	15,477,801	17,271,360	90,843,860
September	14,924,938	16,436,390	105,409,816	15,784,708	18,844,974	87,783,594
October	15,498,719	17,985,457	102,923,078	15,863,016	18,410,073	85,236,537
November	14,725,644	16,305,482	101,343,240	15,514,782	18,568,450	82,182,869
December	13,407,169	15,323,986	99,426,423	15,143,899	18,233,125	79,093,643
	163,506,205	164,480,748		179,383,098	199,715,878	

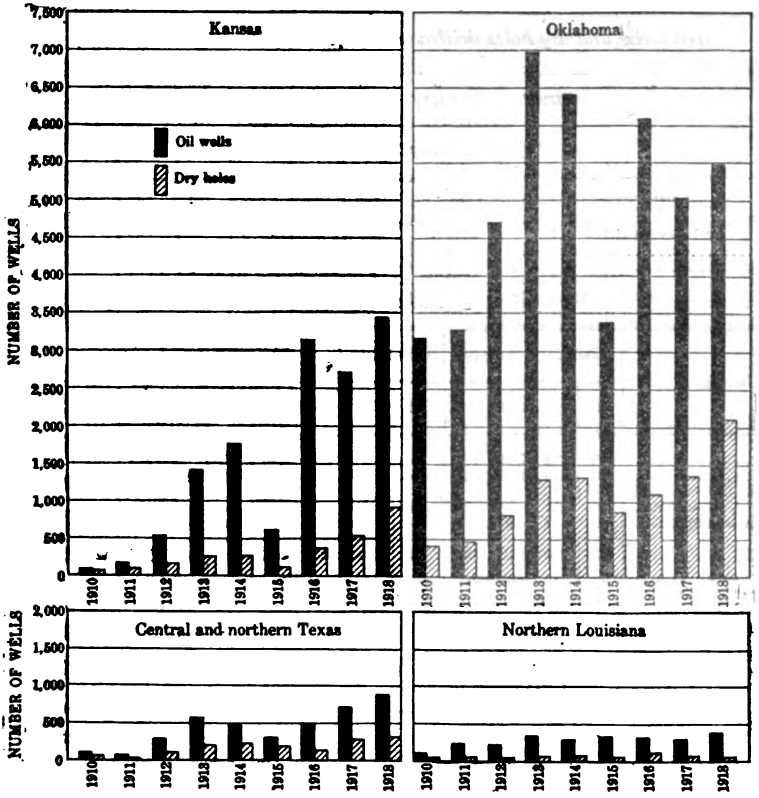

FIGURE 107.—Comparison of number of producing oil wells with dry holes drilled in the Mid-Continent field, 1910–1918.

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SUMMARY OF WELLS DRILLED.

The statistics of field operations presented in the following tables are compiled from trade-journal sources and differ somewhat from those on pages 988–990, which are obtained from reports received directly from the oil producers:

Wells completed in the Mid-Continent field, 1914–1918.

District.	Oil.					Dry.					Total completed.[a]				
	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918
Kansas	1,753	610	3,142	2,712	3,458	270	147	370	538	939	2,340	1,088	3,624	3,427	4,608
Oklahoma	6,410	3,397	6,086	5,027	5,495	1,343	885	1,120	1,360	2,119	8,292	4,624	7,583	6,797	8,376
Northern and central Texas	497	307	500	729	891	222	198	146	292	304	745	528	685	1,045	1,219
Northern Louisiana	302	349	324	302	389	94	89	141	98	73	448	464	520	456	518
	8,962	4,663	10,052	8,770	10,233	1,929	1,319	1,777	2,288	3,435	11,825	6,704	12,412	11,725	14,779

[a] Including gas wells.

Oil wells and dry holes drilled in the Mid-Continent field in 1918.

District.	January.		February.		March.		April.		May.		June.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Kansas	182	44	154	43	263	76	344	109	394	87	416	109
Oklahoma	283	119	302	99	487	157	543	184	557	165	670	235
Northern and central Texas	42	20	55	14	124	22	94	16	112	49	105	32
Northern Louisiana	3	9	26	5	27	8	32	4	34	6	32	7
	510	192	537	161	901	263	1,013	313	1,097	307	1,223	383

District.	July.		August.		September.		Oct.		Nov.		Dec.		Total.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Kansas	372	88	344	101	261	79	284	78	201	62	243	63	3,458	939
Oklahoma	413	149	526	227	432	195	445	197	417	221	420	171	5,495	2,119
Northern and central Texas	90	41	36	28	43	16	46	23	66	16	78	27	891	304
Northern Louisiana	40	2	36	3	51	6	45	13	27	4	36	6	389	73
	915	280	942	359	787	296	820	311	711	303	777	267	10,233	3,435

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Wells completed in the Mid-Continent field, 1914–1918.

Months.	Oil.					Dry.					Total completed.[a]				
	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918
January	976	290	710	526	510	211	76	116	91	192	1,260	422	873	662	753
February	921	307	715	653	537	185	94	138	141	161	1,186	457	911	862	764
March	1,067	250	897	493	901	226	76	187	118	263	1,368	362	1,146	647	1,252
April	1,026	312	1,004	618	1,013	263	85	213	139	313	1,377	452	1,263	809	1,409
May	1,113	293	1,262	679	1,097	246	75	200	197	307	1,461	402	1,554	939	1,497
June	949	297	1,209	728	1,223	156	99	167	169	383	1,177	431	1,410	940	1,733
July	734	264	1,131	812	915	147	76	121	175	280	948	391	1,282	1,026	1,285
August	639	307	829	738	942	107	106	165	183	359	812	467	1,040	951	1,410
September	562	261	668	822	787	101	107	151	268	296	712	448	868	1,171	1,190
October	373	477	541	1,062	820	87	118	134	289	311	556	647	718	1,429	1,229
November	269	686	577	911	711	90	217	92	266	303	448	1,011	698	1,256	1,130
December	333	919	509	728	777	110	190	93	252	267	520	1,214	649	1,033	1,127
	8,962	4,663	10,052	8,770	10,233	1,929	1,319	1,777	2,288	3,435	11,825	6,704	12,412	11,725	14,779

[a] Including gas wells.

Initial daily production of new wells completed in the Mid-Continent field in 1918, in barrels.

District.	January.	February.	March.	April.	May.	June.
Kansas	16,975	22,717	62,649	34,976	31,158	44,766
Oklahoma	19,987	26,119	40,920	36,103	47,500	41,891
Northern and central Texas	1,879	1,681	8,755	4,093	3,850	5,264
Northern Louisiana	60	1,505	14,815	22,495	25,635	10,275
	38,901	52,022	127,139	97,667	108,143	102,196

District.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Kansas	48,171	26,544	11,754	15,294	8,959	10,970	334,933
Oklahoma	30,122	28,570	28,810	24,403	30,843	20,379	375,647
Northern and central Texas	12,135	13,705	24,929	11,980	18,185	40,945	147,401
Northern Louisiana	16,265	16,270	24,720	22,885	10,755	5,425	171,105
	106,693	85,089	90,213	74,562	68,742	77,719	1,029,086

Total and average initial daily production of new wells in the Mid-Continent field, 1914–1918, by districts, in barrels.

District.	Total initial production.					Average per well.				
	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918
Kansas	18,932	11,319	248,846	319,093	334,933	10.8	18.6	79.2	117.7	96.9
Oklahoma	976,244	1,036,170	521,895	365,314	375,647	152.3	305.0	85.8	72.7	68.4
Northern and central Texas	25,003	52,663	49,728	51,153	147,401	50.3	171.5	99.5	70.2	165.4
Northern Louisiana	102,193	198,116	54,871	59,272	171,105	338.4	567.7	169.4	196.3	439.9
	1,122,372	1,298,268	875,340	794,832	1,029,086	125.2	278.4	87.1	90.6	100.6

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Total initial daily production of new wells in the Mid-Continent field, 1914–1918, by months, in barrels.

Year.	January.	February.	March.	April.	May.	June.	July.
1914	38,308	53,507	90,341	73,165	121,193	152,760	95,017
1915	129,224	130,482	106,485	168,789	144,520	127,320	101,981
1916	45,967	70,905	64,541	57,888	87,869	135,023	102,801
1917	45,241	52,613	50,405	40,761	43,230	65,092	88,621
1918	38,901	52,022	127,139	97,667	108,143	102,196	106,693

Year.	August.	September.	October.	November.	December.	Total.	Monthly average.
1914	104,984	96,098	83,923	75,401	137,675	1,122,372	93,531
1915	73,418	56,150	72,337	80,763	63,629	1,255,098	104,592
1916	70,550	81,537	68,716	48,095	41,448	875,340	72,945
1917	85,929	100,122	104,192	64,784	53,842	794,832	66,236
1918	85,089	90,213	74,562	68,742	77,719	1,029,086	85,757

PRICES.

The following table shows the changes in prices of Mid-Continent oil in 1917 and 1918, and the dates on which the changes were made:

Prices of Mid-Continent oil per barrel in 1917 and 1918, by grades.

1917.

Date.	Kansas and Oklahoma.	Healdton, Okla.	Northern Texas.			Northern Louisiana.		
			Corsicana (light), Henrietta, Electra, and Moran.	Powell (heavy).	Thrall, Strawn, and Yale.	Caddo.	De Soto and Sabine.	Red River.
Jan. 1	$1.40	$0.75	$1.40	$0.75	$1.40	$0.85–$1.40	$1.30	$1.10
Jan. 3	1.50					.85– 1.50	1.40	
Jan. 4		.80	1.50	.80	1.50			
Jan. 6	1.60							1.20
Jan. 8		.85	1.60	.85	1.60	.95– 1 60		
Jan. 12	1.70						1.50	
Jan. 13		.90	1.70		1.70			
Jan. 23						.95– 1.70		1.30
Jan. 27							1.60	
Jan. 30								1.40
Mar. 9						.95– 1.80		
Mar. 14						1.00– 1.80		
Mar. 17						1.00– 1.90		
Aug. 1		1.00		.95				
Aug. 13		1.10		1.00				
Aug. 15	1.90							
Aug. 16		1.15	1.90	1.05	1.90			
Aug. 18	2.00							
Aug. 20		1.20	2.00		2.00			
Aug. 22						1.00– 2.00	1.90	1.50

1918.

Date.	Kansas and Oklahoma.	Healdton, Okla.	Northern Texas.			Northern Louisiana.		
			Corsicana (light), Henrietta, Electra, and Moran.	Powell (heavy).	Ranger, Thrall, Strawn, and Yale.	Caddo.	De Soto and Sabine.	Red River.
Jan. 1	$2.00	$1.20	$2.00	$1.05	$2.00	$1.00–$2.00	$1.90	$1.50
Mar. 19	2.25	1.45						
Mar. 20			2.25	1.30	2.25	1.25– 2.25	2.15	1.75
Aug. 12						1.55– 2.25		

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Average monthly price per barrel of Mid-Continent petroleum in 1917 and 1918.

1917.

Date.	Kansas and Oklahoma.	Healdton, Okla.	Northern Texas.			Northern Louisiana.		
			Corsicana (light), Henrietta, Electra, and Moran.	Powell (heavy).	Thrall, Strawn, and Yale.	Caddo.	De Soto and Sabine.	Red River.
January	$1.62	$0.86	$1.62	$0.83	$1.62	$0.92–$1.60	$1.47	$1.26
February	1.70	.90	1.70	.85	1.70	.95– 1.70	1.60	1.40
March	1.70	.90	1.70	.85	1.70	.98– 1.82	1.60	1.40
April	1.70	.90	1.70	.85	1.70	1.00– 1.90	1.60	1.40
May	1.70	.90	1.70	.85	1.70	1.00– 1.90	1.60	1.40
June	1.70	.90	1.70	.85	1.70	1.00– 1.90	1.60	1.40
July	1.70	.90	1.70	.85	1.70	1.00– 1.90	1.60	1.40
August	1.85	1.11	1.84	1.01	1.84	1.00– 1.96	1.70	1.43
September	2.00	1.20	2.00	1.05	2.00	1.00– 2.00	1.90	1.50
October	2.00	1.20	2.00	1.05	2.00	1.00– 2.00	1.90	1.50
November	2.00	1.20	2.00	1.05	2.00	1.00– 2.00	1.90	1.50
December	2.00	1.20	2.00	1.05	2.00	1.00– 2.00	1.90	1.50
Average	1.81	1.01	1.81	.93	1.81	.99– 1.89	1.70	1.42

1918.

Date.	Kansas and Oklahoma.	Healdton, Okla.	Northern Texas.			Northern Louisiana.		
			Corsicana (light), Henrietta, Electra, and Moran.	Powell (heavy).	Ranger, Thrall, Strawn, and Yale.	Caddo.	De Soto and Sabine.	Red River.
January	$2.00	$1.20	$2.00	$1.05	$2.00	$1.00–$2.00	$1.90	$1.50
February	2.00	1.20	2.00	1.05	2.00	1.00– 2.00	1.90	1.50
March	2.10	1.30	2.10	1.15	2.10	1.10– 2.10	2.00	1.60
April	2.25	1.45	2.25	1.30	2.25	1.25– 2.25	2.15	1.75
May	2.25	1.45	2.25	1.30	2.25	1.25– 2.25	2.15	1.75
June	2.25	1.45	2.25	1.30	2.25	1.25– 2.25	2.15	1.75
July	2.25	1.45	2.25	1.30	2.25	1.25– 2.25	2.15	1.75
August	2.25	1.45	2.25	1.30	2.25	1.44– 2.25	2.15	1.75
September	2.25	1.45	2.25	1.30	2.25	1.55– 2.25	2.15	1.75
October	2.25	1.45	2.25	1.30	2.25	1.55– 2.25	2.15	1.75
November	2.25	1.45	2.25	1.30	2.25	1.55– 2.25	2.15	1.75
December	2.25	1.45	2.25	1.30	2.25	1.55– 2.25	2.15	1.75
Average	2.20	1.40	2.20	1.25	2.20	1.23– 2.20	2.10	1.70

KANSAS.

GENERAL STATEMENT.

The production of petroleum in Kansas in 1918 reached the record of 45,451,017 barrels, an increase of 8,914,892 barrels, or nearly 25 per cent over the output in 1917. The production increased steadily throughout the first half of the year, culminating in July, when the average daily output was 144,848 barrels. After this the production fell off rapidly, and the December output was only a little more than half that of July. The great decrease in production toward the end of the year was due to water encroachment, which cut off a large part of the oil. The large output of Kansas comes mainly from Towanda Township, in Butler County.

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The average price received at the wells for this oil was $2.21 a barrel, and the total market value of the output was $100,546,202, a gain of 37 cents in average unit price and of $33,425,629, or 50 per cent, in total market value.

DEVELOPMENT.

In Kansas 4,666 new wells were reported in 1918, an increase of 1,239 wells, or 36.2 per cent over the number completed in 1917. Of the wells completed in 1918, 3,458 were classed as oil wells with an average initial output of 96.9 barrels per day, 269 were gas wells, and 939 were dry holes. The percentage of dry holes to total wells drilled was 20.1 per cent, as compared with 15.7 per cent in 1917 and only 10.2 per cent in 1916.

There was a general increase of activity in the search for new pools and in intensive drilling of old pools and the increase in drilling activity extended over a large part of the State.

Butler County.—During the first part of the year Butler County and in particular the Towanda pool, was the most promising spot in the Mid-Continent field. A number of wells of large capacity had been drilled, and their production was holding up remarkably well. The Shumway lease of the Gypsy Oil Co., sec. 11, T. 26 S., R. 4 E., in the center of the pool, was the best producing lease, and the Shumway well No. 5, completed in September, 1917, was the largest well in the Mid-Continent field and was reported to have an initial output of 26,000 barrels a day. In March, 1918, six months after completion, it was still making 12,000 barrels daily. A number of large wells were drilled in this pool in the early part of the year, but in April a number of the wells began producing salt water and No. 5 on the Shumway lease stopped flowing. By September many wells had been drowned out. The methods of excluding water commonly practiced in the Mid-Continent field having proved inadequate, the outlook at the end of the year was very discouraging.

Early in the year the completion of good wells in sec. 25, T. 26 S., R. 4 E., and in secs. 29 and 32, T. 26 S., R. 5 E., marked an extension of the south end of the Eldorado pool, and a 500-barrel well in the NW. ¼ sec. 2, T. 25 S., R. 5 E., in February extended the Eldorado pool half a mile to the northeast.

Much interest was attracted to what promised to be a new and important pool in northwestern Butler County approximately 18 miles north and a little west of the Eldorado pool, where the Elbing Oil & Gas Co. got a well rated at 400 barrels initial daily production in sec. 18, T. 23 S., R. 4 E., at a depth of about 2,440 feet. This well was 9 miles from the nearest producing well at Potwin. Other tests in this district were poor or were complete failures, and at the end of the year the district showed little promise.

Greenwood County.—Greenwood County, east of Butler County, was thoroughly prospected in 1918. A total of 186 wells was completed, of which 101 were rated as oil wells and 80, or 43 per cent, were dry holes. This county has proved very "spotted" and the large percentage of dry holes has proved discouraging.

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PETROLEUM PRODUCED.

Petroleum produced in Kansas, 1914–1918, in barrels.

Month.	1914	1915	1916	1917	1918
January	260,343	245,606	197,348	2,199,862	3,855,322
February	250,421	207,411	284,726	1,739,952	3,404,699
March	291,631	226,183	353,693	2,498,739	4,070,370
April	262,733	209,173	441,422	2,323,291	4,238,706
May	280,922	211,159	633,726	2,366,411	4,089,150
June	284,835	217,838	834,640	2,681,568	4,113,295
July	292,972	239,216	705,376	3,009,914	4,490,257
August	234,845	247,029	644,667	3,610,946	4,174,275
September	238,908	252,748	951,516	4,101,581	4,042,394
October	238,510	259,494	1,260,585	4,116,002	3,529,384
November	230,848	262,955	1,212,459	4,304,013	2,955,341
December	236,617	244,675	1,217,919	3,583,816	2,487,824
	3,103,585	2,823,487	8,738,077	36,536,125	45,451,017

SUMMARY OF WELLS DRILLED.

The statistics of field operations presented in the following tables are compiled from trade-journal sources and differ somewhat from those on page 988, obtained from reports received directly from the oil producers.

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Wells completed in Kansas, 1914–1918.

County.	Oil.					Dry.					Total completed.[a]				
	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918
Allen	175	49	314	280	255	10	3	8	5	37	198	65	326	236	298
Anderson	1			6	28		4		1	12	1	4		8	42
Bourbon	1		2	2				1		6	1		3	2	15
Butler	5	22	835	994	1,137		4	132	147	263	29	60	1,002	1,160	1,436
Chase								1	1	4			1	1	4
Chautauqua	308	112	441	266	243	38	26	52	75	75	376	164	513	364	361
Coffey	5	3	4	1		1				1	7	3	4	1	1
Cowley	3	2	3	7		8	4	14	29	12	17	18	20	37	13
Crawford					9				5	4				5	13
Dickinson									1					1	
Doniphan									1					1	
Douglas				4	3				2					9	5
Ellsworth									1	1				1	1
Elk			11	44	52	3	2	7	8	46	3	5	19	66	145
Ford										1					
Franklin	163	71	234	142	180	30	22	15	34	55	225	114	252	188	252
Geary										1					1
Greenwood			2	14	101			6	9	80		1	8	23	186
Harper										1					1
Harvey										1					1
Johnson					4					3					8
Kingman										1					1
Labette	8	19	14	38	1	18	3		21		54	29	14	65	1
Linn	2		1		37					8	2		1		49
Lyon								2	1				2	1	
Marion									1	1				1	1
McPherson								1		4			1		4
Miami	131	33	217	182	308	42	15	55	58	76	186	52	274	257	395
Montgomery	691	201	777	336	357	75	49	48	78	106	903	379	860	441	489
Morris								1	3	4			1	3	4
Neosho	221	92	235	297	441	19	9	8	20	75	263	144	249	328	534
Osage								1	2	1			1	2	1
Ottawa								1					1		
Pawnee										2					2
Pottawatomie								1	2				1	2	
Pratt										1					1
Reno										1					1
Rice									1					1	
Saline									1					1	
Sedgwick								2		2			2		2
Shawnee									1	1				1	1
Smith										1					1
Sumner					1			1	4	5		1	1	4	6
Wabaunsee									2	1				2	1
Wilson	27	6	45	137	250	20	4	2	22	32	59	23	50	180	305
Woodson	12		7	22	50	2	2	11	2	15	14	25	18	26	83
Wyandotte					1										1
Miscellaneous						4					7				
	1,753	610	3,142	2,712	3,458	270	147	370	538	939	2,340	1,088	3,624	3,427	4,666

[a] Including gas wells.

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Oil wells and dry holes drilled in Kansas in 1918.

County.	Jan.		Feb.		Mar.		Apr.		May.		June.		July.		Aug.		Sept.		Oct.		Nov.		Dec.		Total.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Allen	7	1	9	1	18	3	16	5	35	2	33	5	29	.....	18	6	17	6	26	5	18	1	29	2	255	37
Anderson	2	.....	3	2	1	.....	1	.....	5	2	.....	.....	.....	.....	4	3	2	2	3	1	4	2	3	.....	28	12
Bourbon	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4	.....	1	.....	.....	.....	1	.....	.....	.....	6
Butler	49	14	72	21	98	12	130	27	120	31	160	37	114	29	125	31	66	19	75	18	50	12	78	12	1,137	263
Chase	.....	1	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	4
Chautauqua	10	5	6	2	38	6	17	4	25	6	33	7	30	7	25	8	14	8	18	10	8	4	19	8	243	75
Coffey	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
Cowley	.....	2	.....	.....	.....	1	.....	2	.....	.....	.....	.....	.....	3	.....	2	.....	1	.....	1	.....	.....	.....	.....	.....	12
Crawford	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	4	.....	.....	.....	.....	.....	.....	.....	.....	.....	3	1	1	3	9	4
Douglas	.....	.....	.....	.....	1	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	3	.....
Elk	3	2	2	1	1	4	6	7	8	2	3	4	5	2	7	5	5	4	.....	3	7	8	5	4	52	46
Ellsworth	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
Franklin	20	1	6	3	13	11	29	5	21	4	11	9	19	4	13	5	18	.....	10	3	8	6	12	4	180	55
Geary	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
Greenwood	2	1	2	1	4	2	9	10	9	2	14	7	12	6	12	12	12	9	7	11	8	6	10	13	101	80
Harper	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	1
Harvey	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	1
Johnson	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4	1	.....	2	4	3
Kingman	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	1
Labette	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....
Linn	.....	.....	.....	.....	.....	.....	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	5	5	20	1	6	.....	4	2	37	8
McPherson	.....	1	.....	1	.....	.....	.....	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4
Marion	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
Miami	11	3	17	7	23	9	37	13	28	10	25	9	32	6	30	3	38	4	22	3	28	5	17	4	308	76
Montgomery	29	4	9	.....	24	14	29	11	55	22	51	14	41	11	40	9	26	5	16	4	27	10	10	2	357	106
Morris	.....	.....	.....	.....	.....	.....	.....	4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4
Neosho	28	4	9	1	29	8	36	10	56	5	58	10	61	9	47	7	28	7	58	10	17	3	24	1	441	75
Osage	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
Pawnee	.....	1	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2
Pratt	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
Reno	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
Sedgwick	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	1	.....	.....	.....	.....	.....	2
Shawnee	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
Smith	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
Sumner	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	1	.....	.....	.....	2	1	1	.....	.....	.....	.....	1	5
Wabaunsee	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
Wilson	21	3	18	1	11	1	19	6	18	.....	24	4	19	3	22	1	30	4	33	4	12	1	23	4	250	32
Woodson	.....	.....	1	.....	1	2	11	1	14	1	5	2	10	5	1	2	.....	1	.....	.....	.....	.....	7	1	50	15
Wyandotte	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	1	.....
	182	44	154	43	263	76	344	109	394	87	416	109	372	88	344	101	201	79	284	78	201	62	243	63	3,458	939

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Wells completed in Kansas, 1914–1918.

Month.	Oil.					Dry.					Total completed.a				
	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918
January	207	47	140	148	182	31	9	9	20	44	266	88	156	171	236
February	194	38	180	196	154	18	24	17	44	43	228	94	209	261	217
March	199	15	254	154	263	32	1	23	35	76	251	23	293	196	357
April	191	10	296	176	344	42	5	49	28	109	254	33	352	215	471
May	230	7	416	190	394	30	7	47	35	87	284	24	477	236	502
June	203	7	436	209	416	10	4	44	26	109	228	28	489	248	543
July	153	12	397	254	372	21	12	16	47	88	201	57	423	319	497
August	115	27	251	249	344	9	14	45	69	101	144	78	305	325	474
September	95	26	235	237	261	17	6	42	51	79	133	79	287	315	370
October	61	68	148	339	284	15	13	29	55	78	119	91	179	415	389
November	50	131	239	300	201	20	26	36	63	62	114	206	279	389	301
December	55	222	150	260	243	25	26	13	65	63	118	287	175	337	326
	1,753	610	3,142	2,712	3,458	270	147	370	538	939	2,340	1,088	3,624	3,427	4,668

a Including gas wells.

Initial daily production of new wells completed in Kansas in 1918, in barrels.

County.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Allen	50	93	326	169	307	363	284	264	305	206	180	322	2,869
Anderson	26	390	100	10	19	.....	.....	34	13	60	21	45	718
Butler	14,835	21,275	59,010	32,093	27,822	40,147	43,742	23,225	8,522	12,632	6,848	8,661	298,812
Chautauqua	316	45	1,215	465	365	1,049	857	689	442	348	395	396	6,582
Crawford	.....	.....	10	.....	.....	40	.....	.....	.....	.....	11	2	63
Douglas	.....	.....	10	10	.....	.....	.....	.....	.....	.....	.....	10	30
Elk	10	10	5	96	58	16	26	44	39	.....	102	60	466
Franklin	263	85	236	271	203	99	163	91	111	61	45	112	1,740
Greenwood	700	185	360	191	575	1,019	1,195	805	975	626	345	410	7,386
Johnson	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	21	.....	21
Labette	.....	.....	.....	40	.....	.....	.....	.....	.....	.....	.....	.....	40
Linn	.....	.....	.....	10	.....	.....	.....	.....	40	166	66	35	317
Miami	98	355	288	372	191	136	259	242	278	185	269	158	2,826
Montgomery	272	61	349	342	436	674	304	322	230	114	219	81	3,404
Neosho	300	55	563	641	682	927	1,083	693	433	594	310	307	6,583
Sumner	.....	.....	.....	.....	.....	.....	.....	.....	.....	12	.....	.....	12
Wilson	105	153	167	168	348	251	170	130	371	290	125	196	2,473
Woodson	.....	10	10	98	152	45	88	5	.....	.....	.....	176	584
Wyandotte	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2	.....	2
	16,975	22,717	62,649	34,976	31,158	44,766	48,171	26,544	11,754	15,294	8,959	10,970	334,933

Total and average initial production of new wells in Kansas, 1914–1918, by counties, in barrels.

County.	Total initial production.					Average per well.				
	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918
Allen	1,896	500	3,771	2,630	2,869	10.8	10.2	12.0	11.4	11.3
Anderson	10	.....	.....	130	718	10.0	.....	.....	21.6	25.6
Bourbon	5	.....	20	30	.....	.....	.....	.....	15.0	.....
Butler	47	3,320	213,633	288,902	298,812	9.4	15.1	255.8	290.6	262.8
Chautauqua	5,379	2,515	10,088	5,722	6,582	17.5	22.5	22.9	22.3	27.1
Coffey	45	20	40	10	.....	9.0	6.7	10.0	10.0	.....
Cowley	150	55	140	154	.....	50.0	27.5	46.7	22.0	.....
Crawford	.....	.....	.....	.....	63	.....	.....	.....	.....	7.0
Douglas	.....	.....	.....	45	30	.....	.....	.....	11.2	10.0
Elk	.....	.....	159	689	466	.....	.....	14.5	15.6	9.0
Franklin	1,360	620	2,666	2,563	1,740	8.3	8.7	11.4	18.0	9.7
Greenwood	.....	.....	18	885	7,386	.....	.....	9.0	63.2	73.1
Johnson	.....	.....	.....	.....	21	.....	.....	.....	.....	5.3
Labette	32	105	85	1,735	40	4.0	5.5	6.1	45.6	40.0
Linn	30	.....	10	.....	317	15.0	.....	10.0	.....	8.6
Miami	920	462	4,199	3,614	2,826	7.0	14.0	19.4	19.8	9.2
Montgomery	6,262	2,505	10,204	4,874	3,404	9.1	12.5	13.1	14.5	9.5
Neosho	2,414	1,182	3,368	5,187	6,588	10.9	12.8	14.3	17.4	14.9
Sumner	.....	.....	.....	.....	12	.....	.....	.....	.....	12.0
Wilson	268	35	365	1,596	2,473	9.9	5.8	8.1	11.6	9.9
Woodson	114	.....	80	327	584	9.5	.....	11.4	14.8	11.7
Wyandotte	.....	.....	.....	.....	2	.....	.....	.....	.....	2.0
	18,932	11,319	248,846	319,093	334,933	10.8	18.6	79.2	117.6	96.9

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Total initial daily production of new wells in Kansas, 1914–1918, by months, in barrels.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.	Monthly average.
1914.....	2,077	2,196	1,950	2,033	2,411	2,178	1,820	1,395	1,066	700	501	615	18,932	1,578
1915.....	843	974	230	105	110	130	225	530	370	700	1,927	5,085	11,319	943
1916.....	2,845	3,875	6,410	9,784	14,429	33,501	28,741	30,569	50,243	35,232	20,402	12,815	248,846	20,737
1917.....	17,532	14,824	16,703	12,843	11,778	26,606	38,974	38,896	58,004	42,444	27,817	12,672	319,093	26,591
1918.....	16,975	22,717	62,649	34,976	31,158	44,766	48,171	26,544	11,754	15,294	8,959	10,970	334,933	27,911

OKLAHOMA.

GENERAL STATEMENT.

For the fourth consecutive year Oklahoma held first rank among the oil-producing States. The total production in 1918 was 103,347,070 barrels, a decrease of 4,160,401 barrels, or 3.87 per cent from the record output of 1917.

A normal decrease in production is shown in the reports from the Glenn, Cushing, and Healdton pools and from Osage County, which is, however, practically offset by increased production from the newer pools, particularly from Okmulgee County and from the Garber and Billings pools.

The average price received at the wells for the petroleum marketed in Oklahoma in 1918 was $2.24 a barrel, and the market value of the output was $231,136,205, a gain of 55 cents in average unit price and of $49,489,224, or 27 per cent, in the total market value of the oil sold, compared with 1917.

A total of 8,376 wells were completed in Oklahoma in 1918, an increase of 1,579, as compared with 1917. This was the largest number of wells drilled in the State since 1913, when the record number was 8,851 wells. Of the wells drilled in 1918, 5,495 were oil wells credited with an average yield of 68.4 barrels for the first day of productive life, 762 were gas wells, and 2,119 were dry holes. The average initial production was lower in 1918 than in any year since 1913 and the percentage of dry holes, 25 per cent, was greater than in any other recent year. The percentage of dry holes to total wells drilled in each of the last nine years was as follows:

Percentage of dry holes to total oil wells drilled in Oklahoma, 1910–1918.

	Percentage of total.		Percentage of total.
1910.....	11	1915.....	19
1911.....	12	1916.....	15
1912.....	14	1917.....	20
1913.....	15	1918.....	25
1914.....	16		

DEVELOPMENT.

NORTHEASTERN OKLAHOMA.

Cherokee district.—The increased price of crude oil resulted in renewed activity in drilling both in the shallow sand division in Craig, Nowata, and northern Rogers counties and in the deep sand division in Washington, western Rogers, and northern Tulsa counties. No new territory of importance was opened in this district. The record is discouraging in that the increase in drilling activity resulted in a slight increase in the percentage of dry holes and in a decrease in average initial yield in both the shallow and the deep sand divisions.

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Osage district.—Osage County was one of the centers of interest in Oklahoma in 1918. The total number of wells reported in the trade periodicals was 1,375, more than twice the number reported in 1917, and nearly five times the number reported in 1916. The search for new territory was extremely active, resulting in a marked increase in the percentage of dry holes—18.6 per cent as compared with 10 per cent in 1917 and 1916. The average initial daily yield of new wells was also much less than in other recent years. The production from Osage County as reported by the Commissioner of Indian Affairs from the records of the agency at Pawhuska was 10,634,076 barrels in 1918, a decrease of 5.18 per cent as compared with 1917. The decrease in production as well as in average initial yield of new wells is attributed to the decrease in productivity of the Osage-Hominy and Boston pools.

The most important discovery of the year was well No. 2 of the American Pipe Line Co. on a gas lease in sec. 17, T. 27 N., R. 8 E., in new territory in the western half of the county. The well was reported to have had an initial production of about 5,000 barrels. The oil lease of the quarter section was sold on November 9 to the Gypsy Oil Co. and, according to trade reports, the well flowed 3,400 barrels the first 24 hours after being connected to a pipe line. The oil was struck at a depth of 2,408 feet in what was reported to be the "Mississippi lime."

Kay County.—The Blackwell pool in Kay County continued to increase in importance in both the shallow and the deep sands. The shallow sand continued to furnish the bulk of the output but a number of deep wells were completed during the year, extending the area of deep sand production very materially. One well in sec. 17, T. 28 N., R. 1 E., drilled by the Southwestern Oil Co. was reported to have started producing at the rate of 1,300 barrels a day.

Attention was attracted to the deep sand possibilities in the Newkirk and Ponca City territory by the drilling in of a small well in sec. 34, T. 27 N., R. 3 E., about the middle of 1917. Other tests scattered over an area some 13 or 14 miles long and 3 or 4 miles wide got good showings of oil. In June, 1918, exceptionally good wells were completed in sec. 15, T. 27 N., R. 3 E., by the Carter Oil Co. and by James J. McGraw and associates. One of these wells started flowing at the rate of 2,000 barrels or more a day. The oil sand is found at approximately 3,100 feet. Later drilling, however, showed this deep sand pool to be limited in extent.

Noble County.—The Billings pool which was opened up in 1917 continued to bring in wells of large initial capacity throughout the first half of the year. The two best wells reported were in sec. 15, T. 23 N., R. 2 W.—one by the Humphreys Petroleum Co., with an initial daily output of 4,000 barrels, and one by the Mid-Co Petroleum Co., which for a short time produced as high as 5,000 barrels daily. By the end of May the production from this pool was reported to be approximately 14,000 barrels from 21 wells, all of the production coming from a sand at approximately 2,100 feet. Outside tests around the Billings pool, however, failed to increase the productive area and the pool appears to be very limited in extent.

A deep test, reported to be the deepest in northern Oklahoma, was drilled by the Humphreys Petroleum Co. in sec. 29, T. 24 N., R. 1 W., and obtained a showing of oil at 4,334 feet.

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Garfield County.—Development in the Garber pool was marked by the discovery of a number of new sands. In December it was reported that at least ten oil sands had been penetrated between 100 and 2,300 feet in depth. This, however, may be an exaggeration inasmuch as there is considerable uncertainty concerning the correlation of the productive sands. The sand found at 2,100 feet—the Garber sand—was reported to be proved around the edges of a territory 3 miles long and 9 miles wide. The upper sands are not productive over so large a territory. The Garber pool is distinctly different from the Billings pool 10 miles northeast in that the Billings pool has furnished a number of very large wells from a small area and from a single sand, whereas the Garber pool has furnished a much larger number of wells with much smaller average production and from a number of different horizons. In the Garber pool the most regular producing sands in 1918 were the Hoy sand at 1,100 feet, the Hotson at 1,500 feet, and the Belveal at 1,750 feet. Indications at the end of the year showed that the sands at 2,100 to 2,300 feet had a much larger producing area than the shallower sands.

Between the Garber and the Billings pools in sec. 15, T. 23 N., R. 2 W., the Oil States Petroleum Co. brought in a 40-barrel well in April at 2,040 feet, which attracted considerable interest as a possibly important new pool.

Four miles east of Garber in sec. 22, T. 22 N., R. 3 W., the Bear Creek Oil Co. got a showing of oil in October.

Payne County.—The Yale-Gray district continued to furnish a number of good wells throughout 1918. Drilling was active, with 73 per cent more wells completed than in 1917, but no new territory of importance was discovered and the average initial production of new wells declined from 395 barrels in 1917 to 137 barrels in 1918.

Creek Nation.—The territory allotted to the Creek Nation includes the counties of Creek, Okmulgee, Muskogee, Wagoner, Okfuskee, and part of Tulsa and embraces the famous Glenn and Cushing pools, as well as a large number of smaller pools.

The total completions of new wells from the Creek district in 1918 was 3,567, an increase of 183, or 5 per cent, over the number drilled in 1917. The average initial production of new wells was considerably higher than in 1917 but not nearly so high as in other recent years.

In Creek County, which includes the famous Cushing and Glenn pools, drilling activity was slightly less than in 1917 and little new territory of importance was discovered. A well drilled by the Eastern Oil Co. in sec. 3, T. 17 N., R. 10 E., near Kellyville, promised an extension of the Kellyville pool and started producing at the rate of 600 barrels a day. A test by the Wolverine Oil Co. in sec. 34, T. 18 N., R. 9 E., 6 miles west of the Kellyville pool started producing 25 to 35 barrels from a sand at a depth of 1,935 feet, but the production declined very rapidly.

In Tulsa County promising territory was opened up near Sand Springs. A well drilled by the Phoenix Refining Co. in sec. 5, T. 19 N., R. 11 E., late in April was rated at 2,400 barrels a day but declined rapidly.

In Wagoner County new wells with initial production of 100 to 600 barrels per day were completed in sec. 29, T. 17 N., R. 15 E., north of the Stone Bluff pool.

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Okmulgee County was noted in oil history in 1918 because of a number of small but very rich pools. These were for the most part found as the result of deep tests drilled in older producing territory. The most prominent was the Youngstown pool in secs. 25 and 36, T. 14 N., R. 11 E., later extended into secs. 1 and 2, T. 13 N., R. 11 E. The pool was discovered as a result of the deepening of an old well on the Huckaby tract in sec. 25 in December, 1917. A number of wells with initial daily capacities of 500 to 2,500 barrels followed in the early spring, but the pool was quickly defined by dry holes around the borders and only a few large wells were completed in the last half of the year. The oil was found at depths of 2,200 to 2,300 feet. The discovery of the Youngstown pool caused considerable deep drilling in Okmulgee County. Scattered production was found in a number of places but the territory has proved "spotted," the individual pools being small but prolific. One of the most promising of the small pools is in sec. 9, T. 13 N., R. 12 E., where wells of 300 to 500 barrels initial daily capacity were found at a depth of approximately 2,700 feet. North of Youngstown in sec. 36, T. 15 N., R. 11 E., at Hamilton Switch, wells of 500 to 1,500 barrels initial production were brought in in the latter part of the summer at a depth of about 2,400 feet.

Other wells of particular interest in Okmulgee County included a 1,400-barrel well in sec. 27, T. 13 N., R. 11 E., at a depth of 2,289 feet and a 1,800-barrel well in the Booch sand in sec. 25, T. 14 N., R. 14 E., in the Bald Hill pool. Both wells were exceptionally large.

The Mounds pool in Tulsa County was active in the early part of the year with several large producers but later attracted little attention. The prolific area in this pool proved to be small and "spotted."

Drilling was active in Muskogee County during 1918 but the new territory opened up consisted in only small pools or extensions of old pools. A small pool in sec. 2, T. 14 N., R. 15 E., midway between Boynton and Haskell, had a good completion in April at about 1,600 feet. The old Sheppard pool had some good completions early in the year, but this, like other pools in Muskogee County, has furnished as a rule only small pumpers with an occasional good well.

SOUTHWESTERN OKLAHOMA.

Carter County.—The production of the Healdton field in 1918 was 15,695,322 barrels, a decline of 2,658,208 barrels, as compared with the record output of 1917. There was a very marked decline in the number of new wells drilled in Carter County, only 272 in 1918 as compared with 519 in 1917. The percentage of dry holes in 1918 was more than 25 per cent, as compared with 9 per cent in 1917 and only 2.5 per cent in 1916. The initial daily capacity of new wells declined from 95 barrels in 1917 to 57.9 barrels in 1918. These records show clearly the exhaustion of the rich possibilities of the Healdton pool.

A large quantity of oil was run into storage in the Healdton field in 1916 and 1917 and the draft from this reserve was very large in 1918.

Near the beginning of the year it was reported that approximately 1,800 wells were producing from the Healdton pool and that new wells were being drilled rapidly. Efforts during the year, however,

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to discover extensions of the pool or to obtain production from deeper sands met with some success, but nothing of great importance was developed.

A well drilled by the Gates Oil Co. in sec. 14, T. 4 S., R. 3 W., to a depth of 3,600 feet in the search for deep productive sand was reported abandoned as a failure. The Fox pool located in T. 2 S., R. 3 W., was developed in 1917 as a rich gas pool of particular interest in 1918. Six or seven miles to the northeast of the Fox pool, in sec. 7, T. 2 S., R. 2 W., the Oklahoma-Fox Oil Co. got a well at 2,500 feet rated at from 200 to 500 barrels.

Cotton and Stephens counties.—The well of the Magnolia Oil Co. in western Stephens County, in sec. 22, T. 1 S., R. 9 W., together with showings of oil in several near-by tests of about the same depth in Cotton and Stephens counties attracted more attention than any discovery since that of the Billings pool. The Magnolia well reached the oil sand at a depth of 2,340 feet in May, 1918, and started flowing at a rate of 200 barrels a day. Later the well was deepened and the rate of flow was temporarily increased to about 400 barrels. This locality is about 30 miles northwest of the Healdton pool and 45 miles northeast of the fields in Wichita County, Tex. In the vicinity are a number of old shallow wells, some of which were drilled years ago but did not produce oil in commercial quantities. The Magnolia Oil Co.'s well is a thousand feet or more deeper than these old wells.

In T. 1 S., R. 10 W., 7 miles southwest of the Magnolia well is the Keyes gas field opened up in 1917, in which a small quantity of oil was found.

In sec. 3, T. 2 S., R. 10 W., on the eastern edge of Cotton County, approximately 7 miles southwest of the Magnolia well, the Wichita Fuel Development Co. got a good well in what appeared to be the same sand at a depth of 2,300 feet.

In sec. 29, T. 1 S., R. 10 W., approximately 10 miles west of the Magnolia well, a small flow of oil was encountered at 2,409 feet.

These discoveries attracted much attention to southwestern Oklahoma and drilling was active throughout the later part of the year. Stephens County was credited with a total of 133 wells completed, of which 75 were rated as oil wells, and Cotton County had 48 completions, of which 22 were oil wells. Most of these wells, however, were of small capacity and no pools of major importance were discovered.

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PETROLEUM PRODUCED.

Petroleum produced in Oklahoma in 1917 and 1918, in barrels.

Month.	Glenn.	Cushing.	Healdton.	Other.	Total.
1917.					
January	625,650	2,220,587	1,208,372	4,509,192	8,564,301
February	548,888	2,032,282	1,395,238	3,953,482	7,929,890
March	667,256	2,365,086	1,732,358	4,709,078	9,474,378
April	682,620	2,137,396	1,681,492	4,437,097	8,938,605
May	682,135	1,997,591	1,668,261	4,615,612	8,963,599
June	687,855	2,136,937	1,662,861	4,508,189	8,995,842
July	722,411	2,730,864	1,713,531	4,396,807	9,563,613
August	704,464	2,096,677	1,685,376	4,554,890	9,041,907
September	614,097	2,157,225	1,615,989	4,625,789	9,012,971
October	613,399	2,420,947	1,444,918	5,081,068	9,560,032
November	608,141	2,427,499	1,334,118	4,773,336	9,143,094
December	710,329	2,015,937	1,209,436	4,343,537	8,318,739
	7,906,245	26,739,628	18,353,530	54,508,068	107,507,471
1918.					
January	529,768	1,924,196	1,480,644	4,114,338	8,048,966
February	461,344	1,529,650	1,298,232	4,179,561	7,708,787
March	479,420	1,964,069	1,428,630	5,081,270	8,953,389
April	481,117	1,560,816	1,326,496	4,730,404	8,098,833
May	495,375	1,667,533	1,408,759	5,169,121	8,740,788
June	436,979	1,591,407	1,389,196	5,103,954	8,521,536
July	448,758	1,891,157	1,293,799	5,494,599	9,128,313
August	424,594	1,579,556	1,273,693	5,182,602	8,460,355
September	412,423	1,670,845	1,226,616	5,415,211	8,725,095
October	417,308	1,710,347	1,221,960	5,758,453	9,108,068
November	399,295	1,874,175	1,208,718	5,659,216	9,141,404
December	401,504	1,729,408	1,138,649	5,381,975	8,651,536
	5,387,885	20,993,159	15,695,322	61,270,704	103,347,070

Petroleum produced in Oklahoma in 1914–1918, in barrels.

Month.	1914	1915	1916	1917	1918
January	5,895,182	6,356,810	8,441,229	8,564,301	8,048,966
February	5,317,883	6,553,703	8,763,238	7,929,890	7,708,787
March	6,845,126	7,428,935	9,631,738	9,474,378	8,953,389
April	6,541,862	11,250,823	8,621,433	8,938,605	8,098,833
May	7,109,701	7,762,963	9,356,086	8,963,599	8,740,788
June	6,843,686	8,363,142	9,047,480	8,995,842	8,521,536
July	6,585,127	9,113,460	8,750,150	9,563,613	9,128,313
August	4,794,055	7,966,760	8,474,831	9,041,907	8,460,355
September	4,352,149	7,874,149	8,761,698	9,012,971	8,725,095
October	6,037,018	7,843,458	9,390,483	9,560,032	9,108,068
November	6,455,123	7,923,866	8,797,850	9,143,094	9,141,404
December	6,864,812	9,477,174	9,027,509	8,318,739	8,651,536
	73,631,724	97,915,243	107,071,715	107,507,471	103,347,070

Petroleum produced in Osage County from Jan. 1, 1903, to Dec. 31, 1918, in barrels.

1903	56,905	1909	4,516,524	1915	8,604,389
1904	652,479	1910	5,892,970	1916	8,852,843
1905	3,421,478	1911	11,707,676	1917	11,214,986
1906	5,219,106	1912	8,169,158	1918	10,634,076
1907	5,143,971	1913	9,009,996		
1908	4,961,147	1914	9,935,692		

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Amount of royalty received by Osage Nation on oil and gas from wells in Osage County, 1913–1918.

Year.	Oil.	Gas.	Total.	Year.	Oil.	Gas.	Total.
1913	$1,033,530	$5,943	$1,039,473	1916	$1,730,674	$497,522	$2,228,196
1914	993,770	10,252	1,004,022	1917	3,369,187	799,345	4,168,532
1915	629,539	13,689	643,228	1918	4,043,011	807,690	4,850,701

The following table shows the number of wells owned in Osage County by the Indian Territory Illuminating Oil Co. and its sublessees and successors:

Oil and gas wells in Osage County, 1903–1918.

Date.	Completed.	Productive.	Gas.	Dry.[a]	Date.	Completed.	Productive.	Gas.	Dry.[a]
Jan. 1, 1903	30	17	2	11	Dec. 31, 1910	1,735	1,175	82	478
Dec. 31, 1904	361	243	21	97	Dec. 31, 1911	2,233	1,562	90	581
June 10, 1905	544	355	34	155	Dec. 31, 1912	2,682	1,887	112	683
Dec. 31, 1905	704	462	45	197	Dec. 31, 1913	3,307	2,323	145	839
June 10, 1906	862	569	55	238	Dec. 31, 1914	3,785	2,654	172	959
Dec. 31, 1906	1,080	716	66	298	June 30, 1916	4,211	2,838	227	1,146
June 30, 1907	1,155	779	67	309	Dec. 31, 1916	4,430	2,968	274	1,188
Dec. 31, 1907	1,277	837	71	369	Dec. 31, 1917	5,246	3,546	344	1,356
Dec. 31, 1908	1,422	936	78	408	Dec. 31, 1918	6,107	4,098	404	1,605
Dec. 31, 1909	1,574	1,027	81	466					

[a] Wells that have been exhausted and abandoned in addition to wells that were dry when drilled in.

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SUMMARY OF WELLS DRILLED.

The statistics of field operations presented in tne following tables are compiled from trade journal sources and differ somewhat from those on pages 988–989, obtained from reports received directly from the oil producers:

Well record in Oklahoma in 1917 and 1918.

District and pool.	1917					1918				
	Wells completed.			Initial daily production (barrels).		Wells completed.			Initial daily production (barrels).	
	Oil.	Dry.	Total.[a]	Total.	Average per well.	Oil.	Dry.	Total.[a]	Total.	Average per well.
Cherokee, deep sand: Bartlesville, Hogshooter.... Copau, Ramsey, Wann.... Dewey.....	475	71	562	10,191	21.5	537	156	736	11,419	21.3
Bird Creek, Owasso, Collinsville, Vera.....	164	44	224	3,557	21.6	142	63	231	2,548	17.9
	639	115	786	13,748	21.5	679	219	967	13,967	20.6
Cherokee, shallow sand: Delaware, Alluwe, Chelsea.....	647	81	731	11,873	18.4	723	96	827	9,400	13.0
Pawnee: Cleveland.....	212	44	273	17,990	84.9	134	73	219	5,663	42.3
Creek: Bald Hill.....	470	109	609	20,596	43.8	387	118	525	11,050	28.6
Cushing, Mannford, Olive..	288	32	336	26,754	92.9	244	87	366	13,104	53.7
Glenn, Tanecha, Sapulpa, Tulsa, Inola, Wicey, Kelleyville, Tuskegee, Kiefer.	804	321	1,208	62,919	78.3	165	93	291	7,031	42.6
Morris, Okmulgee, Henryetta, Youngstown, Tiger Flats.....	319	140	501	13,412	42.0	395	136	597	36,414	92.2
Muskogee, Wagoner, Broken Arrow, Jenks, Rogers.....	367	247	665	26,458	72.1	557	418	1,083	50,953	91.5
Shulter, McIntosh, Okfuskee, Depew.....	14	11	29	815	58.2	15	37	70	235	15.7
Mounds, Hamilton Switch.	21	13	36	1,500	71.4	269	127	446	34,551	128.4
Red Fork, Sand Spring....	.....	.....	.....	.....	.....	114	38	189	5,847	51.3
	2,283	873	3,384	151,454	66.8	2,146	1,054	3,567	159,185	74.2
Healdton[b].....	456	47	519	43,313	95.2	177	70	272	10,242	57.9
Osage.....	530	66	665	57,388	108.3	985	256	1,375	64,547	65.5
Blaine County.....	2	1	3	30	15.0	.....	.....	1	.....	.....
Bryan County.....	.....	.....	.....	.....	.....	1	1	2	20	20.0
Caddo County.....	1	3	5	12	12.0	2	3	7	120	60.0
Comanche County.....	4	2	6	40	10.0	.....	5	5	.....	.....
Cotton County.....	.....	.....	2	.....	.....	22	13	48	1,850	84.1
Garfield County.....	70	22	96	11,679	166.8	142	41	191	22,160	158.1
Grady County.....	.....	.....	.....	.....	.....	1	3	4	20	20.0
Hughes County.....	.....	.....	.....	.....	.....	1	4	5	5	5.0
Jefferson County.....	2	5	7	50	25.0	1	9	10	5	5.0
Kay County.....	69	23	109	33,710	488.6	186	78	315	40,533	217.9
Kingfisher County.....	1	.....	1	15	15.0	.....	.....	.....	.....	.....
Marshall County.....	.....	3	3	.....	.....	3	4	7	25	8.3
Noble County.....	8	4	15	1,695	212.0	44	24	70	28,400	645.5
Payne County.....	78	6	90	20,812	266.8	112	20	157	15,319	136.8
Pontotoc County.....	25	18	48	505	20.2	61	35	108	1,649	27.0
Stephens County.....	.....	4	4	.....	.....	75	41	133	2,537	33.8
Miscellaneous.....	.....	46	53	.....	.....	.....	70	86	.....	.....
	5,027	1,360	6,797	365,314	72.7	5,495	2,119	8,376	375,647	68.4

[a] Including gas wells. [b] Including other tests in Carter County.

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Wells completed in Oklahoma, 1914–1918.

District.	Oil.					Dry.					Total completed.[a]				
	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918
Cherokee, deep	1,331	324	1,087	639	679	236	78	153	115	219	1,789	471	1,294	786	967
Cherokee, shallow	1,472	519	1,105	647	723	77	54	95	81	96	1,558	600	1,219	731	827
Cleveland	77	47	140	212	134	27	26	46	44	73	111	76	197	273	219
Creek	2,651	2,044	2,794	2,283	2,146	719	565	727	873	1,054	3,573	2,784	3,752	3,384	3,567
Healdton[b]	340	289	663	456	177	43	22	17	47	70	392	318	685	519	272
Osage	423	139	227	530	985	99	31	28	66	256	572	190	281	665	1,375
Blaine County				2		1			1		1			3	1
Bryan County					1	1		2		1	1		2		2
Caddo County				1	2	2			3	3	2			5	7
Comanche County	5	5	28	4		2	8	3	2	5	14	18	31	6	5
Cotton County					22	2				13	2			2	48
Garfield County			1	70	142		1	1	22	41		1	2	96	191
Grady County					1					3					4
Hughes County		1			1	4	5	4		4	4	6	4		5
Jefferson County	2		2	2	1	13	13	6	5	9	15	13	8	7	10
Kay County	58	16	30	69	186	49	10	9	23	78	113	32	52	109	315
Kingfisher County				1										1	
Kiowa County	33					1			1	7	36			1	7
Marshall County	3	2			3	2	24	5	3	4	9	37	6	3	7
Noble County				8	44				4	24			3	15	70
Payne County				78	112	2			6	20	2			90	157
Pittsburg County			1			2	3	1	3	1	4	6	6	7	5
Pontotoc County	10	1	6	25	61	10	10	5	18	35	26	23	18	48	108
Stephens County		10	2		75	3	6	5	4	41	7	18	7	4	133
Miscellaneous	5					48	29	13	39	62	61	31	16	42	74
	6,410	3,397	6,086	5,027	5,495	1,343	885	1,120	1,360	2,119	8,292	4,624	7,583	6,797	8,376

[a] Including gas wells.

[b] Including other tests in Carter County.

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Oil wells and dry holes drilled in Oklahoma in 1918.

District.	Jan.		Feb.		Mar.		Apr.		May.		June.		July.		Aug.		Sept.		Oct.		Nov.		Dec.		Total.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Cherokee deep	39	30	41	11	59	15	64	20	64	25	91	18	47	11	72	30	50	12	75	17	40	15	37	15	679	219
Cherokee, shallow	45	4	33	3	69	8	103	12	67	9	102	21	66	7	76	16	41	4	49	3	35	3	37	6	723	96
Cleveland	7	3	9	6	14	3	13	1	5	7	19	5	12	7	13	10	6	6	17	6	6	10	13	9	134	73
Creek	154	50	121	51	182	100	225	111	255	88	245	120	164	73	187	109	109	91	154	82	184	98	146	81	2,146	1,054
Healdton	14	5	26	7	16	4	17	6	23	7	25	8	7	6	12	1	13	6	4	12	8	3	12	5	177	70
Osage	40	11	38	7	97	10	77	16	95	10	98	32	59	21	102	26	82	28	99	38	88	36	110	21	985	256
Bryan County	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	1	1
Caddo County	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	1	.....	.....	.....	.....	2	.....	2	3
Comanche County	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	2	.....	1	.....	.....	.....	.....	.....	5
Cotton County	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	2	.....	6	3	1	1	3	3	1	3	1	2	8	.....	22	13
Garfield County	2	.....	3	1	8	3	10	3	12	2	14	3	13	3	18	1	14	5	9	5	17	11	22	4	142	41
Grady County	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	1	.....	.....	.....	1	.....	.....	.....	1	.....	.....	.....	.....	1	3
Hughes County	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	1	2	.....	1	.....	.....	.....	.....	.....	.....	1	4
Jefferson County	.....	.....	.....	1	.....	1	.....	.....	.....	.....	.....	1	1	.....	.....	.....	.....	1	.....	4	.....	1	.....	.....	1	9
Kay County	6	4	18	6	18	5	21	6	12	9	40	9	13	5	12	8	11	6	10	1	15	11	10	8	186	78
Marshall County	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	1	1	.....	1	.....	.....	1	.....	1	1	.....	.....	.....	.....	3	4
Noble County	3	2	.....	.....	3	.....	4	1	6	1	8	1	4	1	3	2	6	3	4	5	1	8	2	.....	44	24
Payne County	12	.....	10	2	9	1	5	2	15	1	13	.....	9	2	11	2	11	1	6	5	7	2	4	2	112	20
Pontotoc County	.....	.....	3	.....	9	1	3	2	3	2	6	5	3	1	9	3	7	6	5	2	5	6	8	7	61	35
Stephens County	1	.....	.....	1	2	.....	.....	.....	.....	1	6	1	9	4	9	4	18	7	11	7	10	6	9	10	75	41
Miscellaneous	.....	7	.....	2	.....	6	.....	3	.....	3	.....	8	.....	3	.....	10	.....	12	.....	4	.....	9	.....	3	.....	70
	283	119	302	99	487	157	543	184	557	165	670	235	413	149	526	227	432	198	445	197	417	221	420	171	5,495	2,119

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Total and average initial daily production of new wells in Oklahoma, 1914–1918, by districts, in barrels.

District.	Total initial production.					Average per well.				
	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918
Cherokee, deep	19,986	7,926	18,794	13,748	13,967	15.0	24.5	17.3	21.5	20.6
Cherokee, shallow	16,172	10,595	15,972	11,873	9,400	11.0	20.4	14.5	18.3	13.0
Cleveland	3,905	1,328	6,058	17,990	5,663	50.7	28.3	43.3	84.8	42.3
Creek	797,060	913,321	363,778	152,454	159,185	300.7	446.8	130.2	66.8	74.2
Healdton	108,171	85,320	83,940	43,313	10,242	312.3	295.2	126.6	95.0	57.9
Osage	26,787	15,830	24,580	57,388	64,547	63.3	113.9	108.3	108.3	65.5
Blaine County				30					15.0	
Bryan County					20					20.0
Caddo County				12	120				12.0	60.0
Comanche County	59	35	338	40		11.8	7.0	12.1	10.0	
Cotton County					1,850					84.1
Garfield County			50	11,679	22,160			50.0	166.8	156.0
Grady County					20					20.0
Hughes County		40			5		40.0			5.0
Jefferson County	215		85	50	5	107.5		42.5	25.0	5.0
Kay County	5,417	1,630	8,060	33,710	40,533	93.4	101.9	268.7	488.6	217.9
Kingfisher County				15					15.0	
Kiowa County	185					5.6				
Marshall County	15	10			25	5.0	5.0			8.3
Noble County				1,695	28,400				201.9	645.4
Payne County				29,812	15,319				395.0	136.8
Pittsburg County			10					10.0		
Pontotoc County	172	5	120	505	1,649	17.2	5.0	20.0	20.2	27.0
Stephens County		130	110		2,537		13.0	55.0		33.8
Miscellaneous	100					20.0				
	976,244	1,036,170	521,895	365,314	375,647	152.3	305.0	85.8	72.7	68.4

Total initial daily production of new wells in Oklahoma, 1914–1918, by months, in barrels.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.	Monthly average.
1914	27,785	40,344	60,201	61,233	102,674	128,886	84,652	91,886	92,453	81,357	71,488	133,285	976,244	81,354
1915	123,494	117,313	85,070	149,406	124,455	113,210	76,440	48,698	24,730	61,242	64,248	47,874	1,036,170	86,348
1916	32,867	56,386	43,347	40,971	63,180	86,181	59,114	35,759	24,753	30,910	21,365	27,062	521,895	43,491
1917	22,625	32,983	27,643	22,659	22,399	26,413	39,703	37,099	29,043	49,135	29,808	25,834	365,314	30,443
1918	19,982	20,119	40,920	36,103	47,500	41,891	30,122	28,570	28,610	24,408	30,843	20,379	375,647	31,304

Wells completed in Oklahoma, 1914–1918.

Month.	Oil.					Dry.					Total completed.[a]				
	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918
January	684	213	512	322	283	153	56	84	49	119	876	292	626	401	442
February	653	225	458	390	302	138	52	102	71	99	849	297	593	493	442
March	733	193	566	273	487	149	63	136	49	157	929	285	738	343	705
April	725	236	627	356	543	190	56	145	82	184	974	324	805	472	784
May	796	214	750	367	557	178	39	133	127	165	1,044	275	945	587	788
June	660	219	679	402	670	116	51	106	106	235	829	285	802	533	1,005
July	531	205	563	466	413	101	45	78	91	149	668	263	757	577	620
August	469	216	527	396	526	81	58	92	85	227	588	287	649	498	825
September	438	178	362	491	432	72	82	74	175	195	527	292	467	716	701
October	282	364	345	625	445	44	81	71	199	197	372	485	454	871	709
November	180	497	288	528	417	52	164	41	162	221	278	711	349	741	707
December	253	635	311	411	420	69	138	58	164	171	378	828	398	615	648
	6,410	3,397	6,046	5,027	5,495	1,343	885	1,120	1,360	2,119	8,292	4,624	7,583	6,797	8,376

[a] Including gas wells.

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Initial daily production of new wells completed in Oklahoma in 1918, in barrels.

District.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Cherokee, deep	955	946	1,027	1,075	1,591	2,012	592	1,649	914	1,425	971	810	13,967
Cherokee, shallow	395	524	797	905	1,321	1,675	1,082	879	575	377	257	663	9,400
Cleveland	340	805	505	419	160	497	555	427	230	800	75	850	5,663
Creek	5,372	8,954	20,443	14,616	23,892	17,131	16,213	11,177	12,742	10,360	10,638	7,647	159,185
Healdton	729	1,615	1,590	890	2,440	1,025	375	485	352	158	335	257	10,242
Osage	2,052	3,025	7,708	7,303	4,243	3,857	3,204	7,150	5,098	5,749	9,578	5,580	64,547
Bryan County	.....	.....	20	.....	.....	.....	.....	.....	.....	.....	.....	.....	20
Caddo County	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	120	120
Cotton County	.....	.....	.....	.....	.....	90	315	25	430	255	200	535	1,850
Garfield County	175	1,165	860	1,240	2,115	1,635	1,728	1,887	3,100	2,280	4,020	1,955	22,160
Grady County	.....	.....	.....	20	.....	.....	.....	.....	.....	.....	.....	.....	20
Hughes County	.....	.....	.....	.....	.....	.....	.....	5	.....	.....	.....	.....	5
Jefferson County	.....	.....	.....	.....	.....	.....	5	.....	.....	.....	.....	.....	5
Kay County	2,250	6,630	3,905	4,580	2,970	6,328	3,550	2,445	1,950	1,020	3,770	1,137	40,533
Marshall County	.....	.....	.....	.....	.....	5	.....	.....	15	5	.....	.....	25
Noble County	4,900	.....	2,700	4,200	6,925	5,325	1,640	765	1,375	320	75	175	28,400
Payne County	2,818	2,320	950	705	1,758	1,975	595	1,136	1,320	1,000	572	170	15,319
Pontotoc County	.....	135	250	150	85	106	48	225	178	175	82	215	1,649
Stephens County	10	.....	165	.....	.....	232	670	315	531	479	270	265	2,537
	19,987	26,119	40,920	36,103	47,500	41,891	30,122	28,570	28,810	24,403	30,843	20,379	375,647

GULF OIL FIELD.

GENERAL STATEMENT.

The term "Gulf field" as used in this report includes that portion of the Gulf Coastal Plain of Texas and Louisiana in which petroleum is found in domes, associated with rock salt and gypsum. In this area the age of the oil-bearing strata ranges from Cretaceous to Quaternary and the reservoir rock is generally either porous dolomitic limestone or sandstone.

The output of petroleum in the Gulf field in 1918 was 24,207,620 barrels, a decrease of 135,259 barrels, or 0.56 per cent, as compared with the output in 1917. The average price received at the wells was $1.70 a barrel and the market value of the entire output was $41,053,846, a gain of 63 cents a barrel in the average unit price and of $14,966,259, or 57 per cent, in total value, compared with 1917. The market value of the output in 1918 was greater than that of the output in any other year in the history of the Gulf field, and the average price per barrel at the wells was higher than in any other year since 1899, when the entire production amounted to only 530 barrels and consisted of lubricating oil obtained from shallow wells in Hardin and Nacogdoches counties, Tex.

The "posted" or open-market price for the leading grades of oil produced in the Gulf field, which was advanced to $1.80 a barrel on December 30, 1917, remained essentially unchanged throughout 1918.

Despite the increase in price of oil there was a slight decrease in the number of the wells completed, as compared with 1917. In 1918, 1,443 wells were completed in the Gulf field, of which 955 were oil wells, with an average initial output of 331.9 barrels per day, 24 wells produced gas only, and 464, or 32 per cent, were dry holes. The field as a whole showed a marked decrease in the percentage of dry holes and at the same time a corresponding decrease in the average initial production of new wells.

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The principal features of the industry in the Gulf field include the discovery of new sources of oil at West Columbia in Brazoria County and at Hull in Liberty County. Wildcat drilling was fairly active but was much curtailed by lack of drilling supplies.

PETROLEUM PRODUCED.

Petroleum produced in the Gulf field in 1917 and 1918, in barrels.

Month.	1917			1918		
	Coastal Texas.	Coastal Louisiana.	Total.	Coastal Texas.	Coastal Louisiana.	Total.
January	1,676,608	267,043	1,943,651	1,695,162	211,135	1,906,297
February	1,581,365	208,675	1,790,040	1,561,476	195,162	1,756,638
March	1,735,722	231,147	1,966,869	1,849,772	223,983	2,073,755
April	1,881,642	249,470	2,131,112	1,767,940	213,068	1,981,008
May	1,859,077	349,169	2,108,246	1,990,654	242,664	2,233,318
June	1,779,522	261,386	2,040,908	2,058,692	284,805	2,343,497
July	2,039,207	229,459	2,268,666	2,008,108	239,198	2,247,306
August	2,041,481	211,236	2,252,717	1,781,543	214,957	1,996,500
September	2,029,774	211,847	2,241,621	1,880,059	214,931	2,094,990
October	1,872,256	219,684	2,091,940	1,797,368	235,275	2,032,643
November	1,415,368	197,560	1,612,928	1,534,501	227,851	1,762,352
December	1,700,619	193,562	1,894,181	1,544,144	235,172	1,779,316
	21,512,641	2,830,238	24,342,879	21,469,419	2,738,201	24,207,620
Increase or decrease:						
Barrels	+3,171,041	−596,258	+2,574,783	−43,222	−92,259	−135,259
Per cent	+ 17.29	− 17.40	+ 11.83	− 0.20	− 3.25	− 0.56

Petroleum produced in the Gulf field, 1889–1918.

Year.	Production (barrels).	Percentage of total production of United States.	Increase or decrease.		Value.	Yearly average price per barrel.
			Barrels.	Per cent.		
1889	48	.....	.....	.....	$340	$7.084
1890	54	.....	+ 6	+ 12.50	227	4.204
1891	54	.....	.....	.....	227	4.204
1892	45	.....	− 9	− 16.67	225	5.000
1893	50	.....	+ 5	+ 11.11	210	4.200
1894	60	.....	+ 10	+ 20.00	300	5.000
1895	50	.....	− 10	− 16.67	250	5.000
1896	50	.....	.....	.....	250	5.000
1897	50	.....	.....	.....	250	5.000
1898	1,450	.....	+ 1,400	+2,800.00	7,250	5.000
1899	530	.....	− 920	− 63.45	2,650	5.000
1900	0	.....	− 530	− 100.00	0	.....
1901	3,593,113	5.18	+ 3,593,113	.....	630,752	.175
1902	18,014,404	20.29	+14,421,291	+ 401.36	3,766,083	.209
1903	18,371,383	18.29	+ 356,979	+ 1.98	7,418,393	.411
1904	24,631,269	21.03	+ 6,259,886	+ 34.07	8,817,454	.358
1905	36,526,323	27.11	+11,895,054	+ 48.29	8,791,983	.240
1906	20,524,162	16.23	−16,002,161	− 43.81	9,380,091	.457
1907	16,360,299	9.85	− 4,163,863	− 20.29	13,704,469	.837
1908	15,772,137	8.83	− 588,162	− 3.60	9,511,007	.603
1909	10,883,240	5.94	− 4,888,897	− 30.00	7,872,686	.723
1910	9,680,465	4.62	− 1,202,775	− 11.05	7,383,571	.763
1911	10,999,873	4.99	+ 1,319,408	+ 13.63	7,355,681	.669
1912	8,545,040	3.83	− 2,454,833	− 22.32	6,344,184	.742
1913	8,542,494	3.44	− 2,546	− .03	7,993,997	.936
1914	13,118,028	4.94	+ 4,575,534	+ 53.56	8,844,004	.674
1915	20,578,653	7.32	+ 7,460,625	+ 56.87	9,809,301	.477
1916	21,768,096	7.24	+ 1,189,443	+ 5.78	16,416,874	.754
1917	24,342,879	7.26	+ 2,574,783	+ 11.83	26,087,587	1.071
1918	24,207,620	6.80	− 135,259	− .56	41,053,346	1.696
	306,461,919	6.65	.....	.....	201,195,942	.657

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Petroleum produced, value, and average price per barrel in the Gulf field, 1909–1918.

Year.	Coastal Texas.			Coastal Louisiana.			Total.		
	Quantity (barrels).	Value.	Average price per barrel.	Quantity (barrels).	Value.	Average price per barrel.	Quantity (barrels).	Value.	Average price per barrel.
1909	8,852,527	$6,399,318	$0.723	2,030,713	$1,473,368	$0.725	10,883,240	$7,872,686	$0.723
1910	7,929,363	6,100,359	.769	1,750,902	1,283,212	.733	9,680,465	7,383,571	.763
1911	7,275,281	5,340,592	.734	3,724,592	2,015,089	.541	10,999,873	7,355,681	.669
1912	6,459,550	4,739,898	.734	2,085,490	1,604,286	.769	8,545,040	6,344,184	.742
1913	5,825,226	5,550,408	.953	2,717,268	2,443,589	.899	8,542,494	7,993,997	.936
1914	10,617,862	7,164,998	.675	2,500,966	1,680,211	.672	13,118,028	8,844,504	.674
1915	17,469,148	8,369,991	.479	3,109,505	1,439,310	.463	20,578,653	9,809,301	.477
1916	18,341,600	12,925,362	.750	3,426,496	2,491,512	.727	21,768,096	16,416,874	.754
1917	21,512,641	22,938,890	1.066	2,830,238	3,148,697	1.113	24,342,879	26,087,587	1.071
1918	21,469,419	36,554,516	1.703	2,738,201	4,499,328	1.643	24,207,620	41,053,846	1.696

Petroleum produced in the Gulf field, 1914–1918, in barrels.

Month.	1914	1915	1916	1917	1918
January	802,249	1,190,350	2,140,788	1,943,651	1,906,287
February	748,408	1,423,256	1,990,073	1,790,040	1,756,638
March	1,068,009	1,468,789	1,981,721	1,966,389	2,073,755
April	1,227,381	1,431,110	1,811,756	2,131,112	1,981,008
May	1,256,802	1,247,728	1,983,881	2,108,246	2,233,318
June	1,259,829	1,330,051	1,798,647	2,040,908	2,343,497
July	1,125,064	1,538,849	1,724,513	2,268,066	2,247,306
August	1,139,398	1,486,295	1,689,727	2,252,717	1,996,500
September	1,101,244	1,877,809	1,582,284	2,241,621	2,094,990
October	1,222,204	2,437,321	1,667,333	2,091,940	2,032,645
November	1,104,531	2,832,701	1,538,272	1,612,928	1,762,352
December	1,062,914	2,303,394	1,899,101	1,894,181	1,779,316
	13,118,028	20,578,653	21,768,096	24,342,879	24,207,620

Average daily production of petroleum in the Gulf field, 1914–1918, in barrels.

Month.	1914	1915	1916	1917	1918
January	25,879	38,398	69,058	62,698	61,493
February	26,728	50,831	68,623	63,930	62,737
March	34,452	47,380	63,926	63,447	66,895
April	40,913	47,704	60,392	71,037	66,034
May	40,542	40,249	63,996	68,008	72,043
June	41,994	44,335	59,955	68,030	78,117
July	36,292	50,285	55,629	73,183	72,494
August	36,755	47,945	54,507	72,668	64,403
September	36,708	62,594	52,743	74,721	69,833
October	39,426	78,623	53,783	67,482	65,569
November	36,818	94,123	51,276	53,764	58,745
December	34,288	74,303	59,971	61,103	57,397
Average	35,940	56,380	59,476	66,673	66,322

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PIPE-LINE RUNS, DELIVERIES, AND STOCKS.

Pipe-line runs and deliveries to trade of petroleum from the Gulf field and stocks at end of each month in 1917 and 1918, in barrels.

Month.	1917			1918		
	Runs.	Deliveries.	Stocks.	Runs.	Deliveries.	Stocks.
Dec. 31, 1916			9,314,401			
January	1,943,651	1,704,027	9,554,025	1,906,297	1,334,578	8,956,533
February	1,790,040	1,638,164	9,705,901	1,756,638	1,159,891	9,553,280
March	1,966,869	1,701,040	9,971,730	2,073,755	2,458,260	9,168,775
April	2,131,112	1,854,831	10,248,011	1,981,008	2,460,163	8,689,620
May	2,108,246	2,101,179	10,255,078	2,233,318	2,577,992	8,344,946
June	2,040,908	2,329,534	9,966,452	2,343,497	2,305,204	8,383,239
July	2,268,666	2,612,410	9,622,708	2,247,306	2,605,898	8,024,647
August	2,252,717	2,823,467	9,051,958	1,996,508	1,933,360	8,087,787
September	2,241,621	2,443,221	8,850,358	2,094,990	2,380,576	7,802,201
October	2,091,940	1,893,813	9,048,485	2,032,643	1,865,388	7,969,456
November	1,612,928	1,649,163	9,012,250	1,762,352	1,824,499	7,907,309
December	1,894,181	2,521,617	8,384,814	1,779,316	1,518,223	8,168,402
	24,342,879	25,272,466		24,207,620	24,424,032	

PRICES.

Prices paid for Gulf oil per barrel in 1917 and 1918 by the principal pipe-line companies, and dates on which the changes were made.

1917.

Date.	Coastal Texas.						Coastal Louisiana.		
	Batson, Saratoga, Spindletop.	Dayton.	Goose Creek.	Humble.	Sourlake.	Markham.	Edgerly.	Jennings.	Vinton.
Jan. 1	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$0.95	$1.00	$1.00
Apr. 4			.90						
Aug. 31			1.00						

1918.

Jan. 1[a]	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00
Feb. 1[a]	1.35	1.35	1.35	1.35	1.35	1.35	1.35	1.35	1.35
Aug. 1	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80

[a] Prices quoted by Gulf Pipe Line Co. The Sun and Texas companies quoted $1.80 for entire year.

Average monthly prices per barrel of petroleum in the Gulf field, 1917 and 1918.

1917.

Month.	Coastal Texas.						Coastal Louisiana.		
	Batson, Saratoga, Spindletop.	Dayton.	Goose Creek.	Humble.	Sourlake.	Markham.	Edgerly.	Jennings.	Vinton.
January	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$0.95	$1.00	$1.00
February	1.00	1.00	1.00	1.00	1.00	1.00	.95	1.00	1.00
March	1.00	1.00	1.00	1.00	1.00	1.00	.95	1.00	1.00
April	1.00	1.00	.91	1.00	1.00	1.00	.95	1.00	1.00
May	1.00	1.00	.90	1.00	1.00	1.00	.95	1.00	1.00
June	1.00	1.00	.90	1.00	1.00	1.00	.95	1.00	1.00
July	1.00	1.00	.90	1.00	1.00	1.00	.95	1.00	1.00
August	1.00	1.00	.90	1.00	1.00	1.00	.95	1.00	1.00
September	1.00	1.00	1.00	1.00	1.00	1.00	.95	1.00	1.00
October	1.00	1.00	1.00	1.00	1.00	1.00	.95	1.00	1.00
November	1.00	1.00	1.00	1.00	1.00	1.00	.95	1.00	1.00
December	1.00	1.00	1.00	1.00	1.00	1.00	.95	1.00	1.00
Average	1.00	1.00	.96	1.00	1.00	1.00	.95	1.00	1.00

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Average monthly prices per barrel of petroleum in the Gulf field, 1917 and 1918—Contd.

1918.

Month.	Coastal Texas.	Coastal Louisiana.
January	$1.00	$1.00
February	1.35	1.35
March	1.35	1.35
April	1.35	1.35
May	1.35	1.35
June	1.35	1.35
July	1.35	1.35
August	1.80	1.80
September	1.80	1.80
October	1.80	1.80
November	1.80	1.80
December	1.80	1.80
Average	1.51	1.51

SUMMARY OF WELLS DRILLED.

The statistics of field operations presented in the following tables are compiled from trade-journal sources and differ somewhat from those on pages 989–990, obtained from reports received directly from the oil producers.

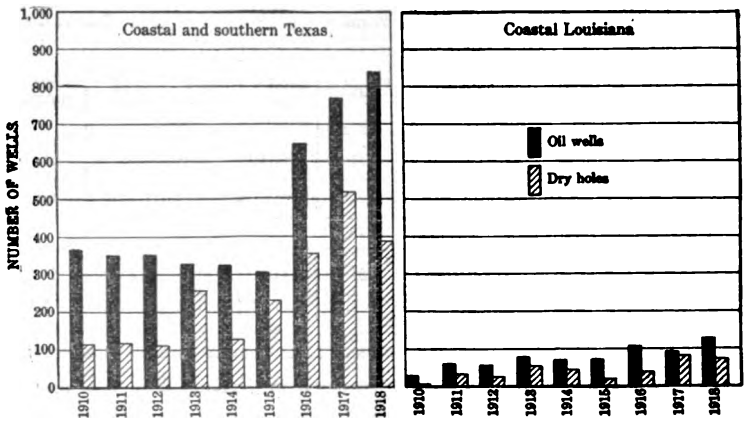

FIGURE 108.—Comparison of number of producing oil wells with dry holes drilled in the Gulf field, 1910–1918.

Wells completed in the Gulf field, 1914–1918.

District.	Oil.					Dry.					Total completed.[a]				
	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918
Coastal and southern Texas	323	306	647	770	838	129	230	354	517	389	463	541	1,028	1,336	1,249
Coastal Louisiana	72	73	104	93	117	45	26	41	81	75	118	101	146	178	194
	395	379	751	863	955	174	256	395	598	464	581	642	1,174	1,514	1,443

[a] Including gas wells.

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Oil wells and dry holes drilled in the Gulf field in 1918.

District.	January.		February.		March.		April.		May.		June.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Coastal and southern Texas	43	28	53	28	72	36	72	29	102	34	85	37
Coastal Louisiana	7	7	8	2	8	2	8	10	12	8	13	9
	50	35	61	30	80	38	80	39	114	42	98	46

District.	July.		August.		September.		October.		November.		December.		Total.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Coastal and southern Texas	79	33	81	40	77	33	56	26	66	27	52	38	838	389
Coastal Louisiana	9	10	10	.....	7	10	13	11	13	1	9	5	117	75
	88	43	91	40	84	43	69	37	79	28	61	43	955	464

Wells completed in the Gulf field, 1914–1918.

Month.	Oil.					Dry.					Total completed.[a]				
	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918
January	45	24	47	57	50	5	11	32	29	35	51	35	84	95	87
February	26	28	56	60	61	8	7	34	39	30	37	35	92	104	91
March	26	20	74	87	80	13	16	27	34	38	39	36	101	127	119
April	24	22	82	81	80	21	23	31	41	39	46	45	115	126	122
May	45	31	94	97	114	14	14	50	77	42	61	45	149	178	159
June	35	38	67	90	98	11	35	45	69	46	46	74	115	168	147
July	43	38	65	92	88	21	36	37	61	43	65	75	104	159	132
August	35	34	60	65	91	26	18	34	49	40	63	53	96	114	135
September	28	38	48	71	84	10	27	28	80	43	39	65	78	154	129
October	25	26	45	80	69	18	13	19	51	37	43	39	64	135	109
November	34	42	49	41	79	18	30	26	33	28	53	73	79	76	108
December	29	38	64	42	61	9	26	32	35	43	38	67	97	78	105
	395	379	751	863	955	174	256	395	598	464	581	642	1,174	1,514	1,443

[a] Including gas wells.

Initial daily production of new wells completed in the Gulf field in 1918, in barrels.

District.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Coastal and southern Texas	8,420	19,622	36,095	16,725	28,365	50,346	21,045	15,495	36,942	14,045	12,146	21,001	280,247
Coastal Louisiana	615	600	2,450	3,710	4,660	8,575	1,135	830	365	9,790	1,140	2,820	36,690
	9,035	20,222	38,545	20,435	33,025	58,921	22,180	16,325	37,307	23,835	13,286	23,821	316,937

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Total and average initial daily production of new wells in the Gulf field, 1914–1918, by districts, in barrels.

District.	Total initial production.					Average per well.				
	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918
Coastal and southern Texas	160,695	292,541	388,422	445,263	280,247	497.5	956.0	600.3	578.3	334.4
Coastal Louisiana	82,914	45,185	111,310	46,210	36,690	1,151.6	619.0	1,070.3	496.9	313.6
	243,609	337,726	499,732	491,473	316,937	616.7	801.1	665.4	569.5	331.9

Total initial daily production of new wells in the Gulf field, 1914–1918, by months, in barrels.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.	Monthly average.
1914	10,551	7,101	31,975	40,624	16,071	23,652	26,085	13,043	23,685	15,520	17,772	12,530	243,609	20,301
1915	15,680	15,398	6,485	8,020	13,285	20,265	18,300	16,875	40,053	68,815	89,050	25,500	337,726	28,144
1916	77,380	67,882	81,259	30,083	59,280	42,775	19,049	15,684	19,010	25,670	17,880	43,780	499,732	41,644
1917	41,865	43,790	65,755	42,496	50,450	50,053	34,910	57,330	36,577	31,238	14,717	21,392	491,473	40,956
1918	9,035	20,222	38,545	20,435	33,025	58,921	22,180	16,325	37,307	23,835	13,286	23,821	316,937	26,411

TEXAS.

GENERAL STATEMENT.

Petroleum marketed in Texas from field sources in 1918 amounted to 38,750,031 barrels, an increase of 6,336,744 barrels, or 19.55 per cent, over the output in 1917. Of this record output the stratum division, including the oil districts of central and northern Texas, which are classified as part of the Mid-Continent field (see pp. 1052–1059), contributed 17,280,612 barrels, or 44.6 per cent of the total, and the salt-dome division of the Gulf Coastal field, including the oil fields of southeastern Texas, contributed 21,469,419 barrels, or 55.4 per cent. The increase is credited largely to the newly developed fields of north-central and northern Texas—Ranger, Breckenridge, and Burkburnett. The actual output of the wells in these new fields was probably somewhat larger than the quantity marketed; the difference, however, was undoubtedly small, inasmuch as the marketing companies were able to take care of the greater part of the production either by pipe-line or railway shipments or by the construction of storage facilities near the points of production.

The average price received at the wells for all grades of oil marketed in Texas in 1918 was $1.93 a barrel, a gain of 61 cents in average unit price compared with 1917. The market value of the crude oil sold in 1918 was $74,867,537, a gain of $31,975,982, or 75 per cent, over the market value of the output in 1917. Of this sum the share credited to the stratum division was $38,313,019, or 51.2 per cent, and that to the salt-dome division was $36,554,518, or 48.8 per cent, the average unit price in the stratum division being $2.22 a barrel—39 cents higher than in 1917—and in the salt-dome division being $1.70 a barrel—64 cents higher than in 1917.

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DEVELOPMENT.

The drilling of new wells in 1918 was stimulated by increase in prices and by the discovery late in 1917 of new and promising pools in Eastland, Stephens, and Brown counties. Development was, however, much retarded by greatly increased cost of drilling material, lack of storage facilities, congestion of railway transportation, scarcity of labor, scarcity of water, and in the latter part of the year by the epidemic of influenza. In all, 2,468 wells primarily for petroleum were drilled in Texas in 1918, an increase of 87 over the number drilled in 1917. Of these 1,729 were classed as oil wells with an average initial production of 247.3 barrels daily, 46 produced gas only, and 693, or 28 per cent, were dry holes.

STRATUM DIVISION.

In central and northern Texas a total of 1,219 wells were completed in 1918, of which 891 were classed as oil wells, with an average initial production of 165.4 barrels per day, 24 produced gas only, and 304 were dry holes. As compared with 1917, the year marked a decided increase in production and in number of new wells drilled, a decrease in the percentage of dry holes, and more than 100 per cent increase in the average initial yield of new oil wells.

The features of outstanding importance were the gradual development of the deep-sand pools in Eastland and Stephens counties, the rapid development of the shallow-sand pool at Brownwood in Brown County, the discovery and rapid development of a very prolific pool largely within the town limits of Burkburnett in Wichita County, and the discovery of the Duke pool in Comanche County. The discovery and development of these prolific pools attracted general attention to the Texas fields, and an extensive campaign for the discovery of new territory was inaugurated. Activity spread from these centers throughout all of central and western Texas. Operations were greatly retarded in 1918, but an enormous increase in drilling activity was promised for 1919.

Wichita County.—Wichita County showed a marked increase in production, in the number of new wells drilled, and in the average initial yield of new wells in 1918, as compared with 1917. The older producing areas at Electra and southwest of Burkburnett combined to furnish good producers throughout 1918. The newer development at Sunshine Hill, 6 miles northeast of the Electra pool, attracted considerable attention during the early part of the year. In April this pool was reported to have 75 producing wells in an area of about 50 acres. The principal producing sand was reached at about 500 feet. The Ramming pool, approximately 3 miles east of Sunshine Hill, was reported in April to have 216 wells producing from a depth of about 1,700 feet.

In the last week of July the Fowler Oil Co. brought in a well reported to have started flowing at 2,500 to 4,000 barrels daily at the north edge of Burkburnett town site, some miles from the nearest productive territory. The oil was found at a depth of 1,735 feet. A campaign of town lot development immediately ensued. The drilling campaign was carried out largely by small local companies and a large number of wells were drilled in a comparatively small area. The area proved very prolific; the majority of the wells

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started flowing at 100 to 500 barrels a day, but several wells started at 1,000 to 3,000 barrels daily.

In the Iowa Park field, south and west of Iowa Park, new territory was opened up by the completion of wells on the Watkins farm. Before the end of the year this shallow pool furnished a number of good producers.

In April, 1918, Electra field was reported to have 1,199 producing wells, Burkburnett 918, Sunshine Hill 75, Iowa Park 56, and Holliday 11.

Clay County.—The Petrolia field in Clay County attracted little attention during 1918. Production declined markedly and only 11 wells were completed in the county, of which 6 were dry holes. In April the Petrolia pool was reported to have 502 producing wells.

North-central Texas.

The petroleum fields in north-central Texas include those of Eastland, Stephens, Brown, Comanche, Shackelford, and Palo Pinto counties, and prospective territory in adjoining counties. The shallow pools of Strawn, Moran, and Brownwood are included in the north-central Texas field as well as the deep-sand pools of Ranger, Breckenridge, Caddo, and Duke. Throughout the greater part of the year the deep-sand pools, of which the Ranger pool is the most extensively developed, became the central interest among the oil operators not only in Texas but in the whole country. Toward the latter part of the year the interest was divided between the country centering around Ranger and the Burkburnett district in Wichita County. The oil in the deep-sand pools is obtained from several different horizons in the so-called Bend series, which is of Pennsylvanian and Mississippian age.

The J. H. McClesky well, of the Texas Pacific Coal & Oil Co., near the town of Ranger, which was completed on October 25, 1917, was the discovery well of the Ranger pool and marked the beginning of the intensive development of the deep-sand territory. This well started flowing at the rate of 1,200 barrels a day. The Parks well in the vicinity of Breckenridge in Stephens County was, however, the first well which produced oil from the Bend.

The Ranger pool proper lies in northeastern Eastland County, in and to the west of the town of Ranger. The oil is obtained at depths of from 3,200 to 3,500 feet from the sandy lenses in the Marble Falls limestone. Up to March 20, 1918, the district had 4 producing wells, all the property of the Texas Pacific Coal & Oil Co. The Davenport well, an offset to the discovery well, came in on March 13, flowing at the rate of 1,000 barrels a day, and the Hegaman well, northeast of the town, developed a production of 200 barrels a day on March 14.

The Walker well, at the edge of the town of Ranger, was first rated as a gasser but gradually developed into a producing oil well. Interest in the field was greatly extended by the bringing in 4 miles south of Ranger, in June, of the Brewer well No. 1, with a reported initial production of 3,200 barrels a day, and by the Jones well, west of Ranger, which was completed in July, with an initial production of 4,500 barrels. The largest well drilled during the year, however, was the No. 1 Emma Terrill, of the Prairie Oil & Gas Co., which was credited with an initial yield of 11,000 barrels a day. By the end of the year producing wells were scattered over an area of approximately 25

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square miles. About 50 wells were producing oil, approximately 20 wells were shut down on the top of the sand awaiting storage, 50 wells were drilling below 3,300 feet, and 80 additional wells had been started. During the year a total of 88 completed wells was credited to Eastland County, of which 62 were classed as producing oil wells having an average initial production of more than 1,000 barrels a day.

Eight miles east of Ranger, on the Allen Ranch, the Sun Co. drilled to the top of the Ranger sand, where the tools were lost and never recovered. With the sand just entered at 3,037 feet, the well started flowing 300 barrels daily, of which 50 per cent was oil and 50 per cent salt water. At the end of the year this territory looked very promising.

Near Olden Switch, midway between Ranger and Eastland, several wells of small capacity were obtained in a sand about 1,350 feet below the surface. These wells gave promise of a good shallow pool, but received scanty attention on account of the greater promise from the deep sands. A total of 21 dry holes was reported from Eastland County in 1918, most of which were drilled in wildcat territory in the hope of obtaining extensions of the Ranger pool.

Stephens County.—The Breckenridge pool in Stephens County, 4½ miles south of the town of Breckenridge, was developed around the original Parks well, which was drilled in 1916, but no extensive drilling campaign was begun until after the Ranger discovery, so that the real development was actually the result of that of Ranger. At the end of the year this pool contained 10 producing wells of which the more important were the Lauderdale, which started flowing 1,000 barrels a day, and the Fincher No. 2, which was producing 2,200 barrels daily one week after being drilled in. At the end of the year there were 44 locations or wells drilling in the vicinity of the Breckenridge pool, scattered over an area of 4 by 10 miles.

The Caddo pool, extending southwesterly from the town of Caddo which is 12 miles east of Breckenridge, was discovered during the year 1918 and at the end of the year had 5 producing oil wells, 2 gas wells, and 2 dry holes, in addition to 30 locations and wells drilling. The most important well was the Sandidge well of the Texas Co., which started flowing at the rate of 1,000 barrels a day. The Veale pool, 9 miles south of Caddo, centers around the Veale well of the Texas Pacific Coal & Oil Co. In this well a 20-foot gas sand was found at a depth of 3,960 feet which produced several million cubic feet of gas and a little oil. The production of oil increased greatly and at the end of the year the well was flowing 500 barrels a day. The only other producing well in this pool at the end of the year was the Sudderth, 2 miles west of the Veale. There were, however, 4 producing gas wells and 28 locations or wells drilling scattered over an area of 50 square miles around the Veale well as the center. Much attention was attracted to the well of the Texas Co., on the ranch of the Black Bros., 4½ miles east and 12 miles north from the town of Breckenridge. This well struck oil in the Smithwick shale and started flowing at 200 barrels a day.

Comanche County.—One of the most important discovery wells of the year was the Duke well in northern Comanche County near the eastern county line, which was completed on September 2, 1918. At the end of the year 2 wells had been completed in this pool, of

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which the Knowles well, an offset to the Duke, was the larger. This well started flowing at the rate of 4,500 barrels a day.

Brown County.—The shallow pool at Brownwood in Brown County was intensively developed in the early part of the year. The wells listed in the trade journals as in Brown County numbered only 105 for the year 1918 and 4 for 1917, but apparently a great many small wells were completed which were not listed, inasmuch as a news report of May 16, 1918, states that 319 wells were producing at that time and that at least 40 wells were finished and had not been placed on the pump. The wells were all small but were profitable on account of the very shallow depth—150 to 300 feet—to which it was necessary to drill. Interest in this pool declined after the middle of the year, and only 7 completions are reported for the last four months.

In addition to the promising pools developed in northern central Texas in 1918, several good showings of oil or gas were found at scattered localities which for a time at least seemed to promise new productive pools. Particular interest was centered in northeastern Coleman County and in the deep-sand possibilities of Brown County. According to news reports, the Magnolia Oil Co. completed 2 tests on the Morris tract, in northeastern Coleman County, which started flowing approximately 120 barrels a day each. On the Walter Gray farm, also in northeastern Coleman County, Mitchell Bros. obtained oil at a depth of 2,145 feet. The well was reported to have started flowing at the rate of 150 barrels a day.

An important test by the Pecan Bayou Oil Co., on the Matlock farm southeast of Brownwood, obtained a strong flow of gas at a depth of 2,300 feet. A test of the Tidal Oil Co., on the Underwood farm, 16 miles south of Ranger, was reported in July to have a showing of light-green oil. In August it was reported that the test of the Texas Co., on the Graham farm, 13 miles west of Graham in Young County, had reached an oil sand at 3,606 feet and was producing 40 barrels a day.

The following is a list of dry holes abandoned in 1918 as reported in the January, 1919, number of the Oil Trade Journal:

EASTLAND COUNTY.

Atlas Oil Co.; No. 1 Mann; in the northeast corner of sec. 4, T. Mullrune survey; depth, 3,500 feet.
Beaver Valley Oil & Gas Co., No. 1 Lyons; F. Blundell survey; depth, 3,480 feet.
Cunningham et al; No. 1 R. T. Riddle, 12 acres; F. Blundell survey; depth, 3,520 feet.
Humble Oil & Refining Co.; No. 1 Patton; depth, 3,500 feet.
Havemeyer & Seaman, No. 1 Alsobrook; block 1, sec. 14, H. and T. C. survey, No. 200; depth, 3,525 feet.
Mid-Kansas Oil & Gas Co.; No. 1 J. R. Jackson; 330 feet east and 330 feet south of center of block 4, sec. 66, T. P. survey, 5 miles southeast of Caddo; depth, 3,745 feet.
Prairie Oil & Gas Co.; No. 1 Jack Phillips; J. Bledsoe survey, 2 miles southeast of Ranger; depth, 4,210 feet.
Prairie Oil & Gas Co.; No. 1 Falls; 4 miles south of Ranger; abandoned at 4,000 feet.
Prairie Oil & Gas Co.; No. 1 Vick; James Lehea survey, 1 mile east of Ranger; depth, 3,525 feet.
Sammies Oil Co.; No. 1 Dean; northeast corner of 2-acre tract, F. Blundell survey; depth, 3,709 feet.
System Oil Co. (Tidal Oil Co.); No. 1 E. R. Underwood; O. S. Richardson survey, 9 miles southeast of Ranger; depth, 3,584 feet.
Texas Pacific Co.; No. 1 W. S. Davenport; depth, 3,700 feet.
Texas Pacific Co.; No. 1 V. V. Cooper; Wm. Frels survey; depth, 3,750 feet.

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Texas Pacific Co.; No. 2 W. R. Hodges heirs; F. Blundell survey; abandoned at 325 feet on account of Sammies Oil Co.'s offset on Dean being dry.
Texas Pacific Co.; No. 1 J. M. Rusk; depth, 3,800 feet.
Texas Pacific Co.; No. 1 Eva McDowell; F. Blundell survey, northwest part of Ranger; depth, 3,508 feet.
Texas Pacific Co.; No. 1 Pitcock; Wm. Frels survey, ½ mile south of Ranger; depth, 4,020 feet.
Texas Pacific Co.; No. 1 Lane; depth, 3,505 feet.

STEPHENS COUNTY.

Gulf Production Co.; No. 1 A. M. Fincher; in northwest corner northwest ¼ block 6, sec. 12, T. P. survey, 5½ miles southeast of Breckenridge; depth, 3,775 feet.
Texas Pacific Co.; No. 1 Barrow; northeast corner G. W. Dolley survey; depth, 3,583 feet.
Texas Pacific Co.; No. 1 Booher; 300 feet each way from northwest corner southeast ¼ block 7, sec. 28, T. P. survey; depth, 3,445 feet.
Texas Pacific Co.; No. 1 W. H. Corbett; near middle of west line of T. E. & L. survey; depth, 2,165 feet.
Texas Pacific Co.; No. 1 Gantt; 1 mile south of Caddo; depth, 3,360 feet.
Texas Pacific Co.; No. 1 Hughes; northwest corner A. B. & M. A. survey; depth, 2,360 feet.
Texas Pacific Co.; No. 1 T. D. Lauderdale; northwest corner block 6, sec. 38, T. P. survey; depth, 1,975 feet.
Texas Pacific Co.; No. 1 Mrs. McNabb (Lacasa); 250 feet southwest from southeast corner of block 4, sec. 69, about 7 miles southeast of Caddo; depth, 1,800 feet.
Texas Pacific Co.; No. 1 Porter Brown (Lacasa); block (?), sec. 90, T. P. survey; depth, 3,510 feet.
Texas Pacific Co.; No. 1 Wright; block 5, sec. 43, ½ mile southwest of Caddo; depth, 3,550 feet.
Texas Co.; No. 1 Keathley; 990 feet south 312 east from northwest corner T. E. & L. survey No. 3357, 6 miles southeast of Breckenridge; depth, 3,326 feet. (Reported to have resumed drilling in this test.)

COLEMAN COUNTY.

Graham, Ludlow & Thomas; No. 1 Abney; Kerr County school lands; depth, 2,611 feet.
Magnolia Petroleum Co.; No. 1 Sealy; John Sealy survey, 11 miles northeast of Coleman; depth, 3,620 feet.
Magnolia; 4 Morris ranch; David Breeding survey No. 728; depth, 3,980 feet.
Mutual Petroleum Co.; No. 1 Babbington; sec. 279, E. T. survey; depth, 2,330 feet.
Skelley & Sankey; No. 1 Gray; Mark Isod survey; depth, 2,000 feet.
Wood & Wooley; Burnet County school lands; depth, 1,520 feet.

CONCHO COUNTY.

Schultz Oil Co.; No. 1 M. Swenson; block 12, T. & N. O. survey; depth, 1,430 feet.

PALO PINTO COUNTY.

Empire Gas & Fuel Co.; No. 1 Watson; Daniel Brooks survey, 8 miles northwest of Palo Pinto town; depth, 4,065 feet.
Empire Gas & Fuel Co.; No. 1 Watson; Daniel Brooks survey; depth, 4,059 feet.
E. G. Johnson et al.; No. 1 Smith; block A, sec. 14, T. P. survey; depth, 4,400 feet.
Owen & Wilson; No. 1 John Oakes; 165 acres, Robert Evans survey, 6 miles southwest of Mineral Wells; depth, 4,450 feet.
Slim Jim Oil Co.; No. 1 R. P. Lee; T. E. & L. survey, 3 miles northwest of Graford; depth, 2,250 feet.
Texas Pacific Co.; No. 1 Gillespie; 27 acres, John Bird survey, 9 miles south of Palo Pinto town; depth, 1,505 feet.
Texas Pacific Co.; No. 2 Wilbar; M. Latham survey, 1,500 feet south of No. 1; depth, 1,817 feet.

COKE COUNTY.

Robert Lee Oil Co.; No. 1 Locke; Carl E. Hohlre survey; depth, 2,110 feet.
W. W. Skinner et al.; No. 1 McCabe survey No. 31; depth, 700 feet.

PARKER COUNTY.

Texas Pacific Co.; No. 1 Rock Creek; sec. 375, M. E. P. & P. survey; depth, 3,615 feet.

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ERATH COUNTY.

Texas Pacific Co.; No. 1 Long; John McLennan survey; depth, 3,435 feet.

BROWN COUNTY.

Collins et al.; No. 1 Greeley; R. Rose survey; depth, 1,590 feet.
Hart & Son; No. 4 Coyle; R. W. Shannon survey; depth, 2,038 feet.
Oil States Petroleum Co.; No. 1 Alvis; 100 feet east 300 feet north from southwest corner northeast ¼ sec. 37, 18 miles northwest of Brownwood; depth, 3,160 feet.

MONTAGUE COUNTY.

Four-in-One Oil Co.; No. 1 Mays; Belcher subdivision; depth, 700 feet.

Central Texas.

Development in the Corsicana and Powell districts, Navarro County, and in the Thrall district, Williamson County, was practically at a standstill during 1918 and the production from these pools showed a normal decline. According to a new report in June, Navarro County had 953 producing wells with an average output of 1 barrel per day per well.

Eastern Texas.

In Panola County, where disappointing results were reported in 1917, of a total of 6 wells drilled in 1918 only 1 was reported as an oil well. Better results were obtained in Shelby County where 4 wells were reported as completed, all of which were rated as producers.

SALT-DOME DIVISION.

Coastal Texas.

The output of crude petroleum from the producing districts of the salt-dome division of southeastern Texas in 1918 was 21,469,419 barrels, a slight decrease from the output in 1917. The market value, however—$36,554,518—was greater by $13,615,628, or 59 per cent, than the value of the output in 1917.

Damon Mound, Goose Creek, Saratoga, and Spindletop increased their productive capacity during the year, while Humble, Sourlake, and other smaller pools decreased considerably. There were 1,249 wells drilled primarily for oil during the year as compared with 1,336 drilled in 1917. Of the wells drilled, 838 were rated as oil wells, with an average initial output of 334.4 barrels a day, 22 wells produced gas only, and 389 wells were rated as dry holes. The total showed a slight reduction in production and in total number of new wells drilled, an increase, however, in the number of oil wells completed, and a marked decrease in the percentage of dry holes. The average initial production of new wells was very much less than in 1917.

The outstanding feature during the year was the elevation of two districts, previously rated as of little consequence, into the rank of important producing territory. These districts were at West Columbia in Brazoria County, about 9 miles from Damon Mound, and near Hull in Liberty County. At West Columbia drilling had been carried on intermittently for 10 years or more, the earlier attempts having obtained small quantities of oil at shallow depths. Interest in the pool was revived in January by the completion of the Tyndall-Wyoming Oil Co.'s well No. 2, on the Hogg tract, which was reported to have started flowing at from 200 to 300 barrels a day for a short time. In June the Texas Co.'s No. 7 well, on the Kaiser tract, was reported

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to have started flowing at 2,000 barrels a day from a depth of 2,570 feet. The largest well reported drilled during the year was brought in on December 3 by the Humble Oil & Refining Co., in block 25 on the Hogg tract. This well was reported to have started flowing at the rate of 10,000 barrels a day. At the end of the year West Columbia was firmly established as one of the important producing districts of coastal Texas.

The development of the important pool 2½ miles south of Hull in Liberty County was carried out largely by the Republic Production Co. on an 800-acre tract, the property of the Houston Oil Co. Well No. 1 near the center of this tract was reported abandoned in salt water around 1,400 feet. No. 2, 2,500 feet southeast of No. 1, was abandoned in salt water at 2,700 feet. No. 3, northeast of No. 1, was also reported abandoned in salt water at 3,700 feet but later was tested between 2,200 and 2,300 feet and developed a good producing well which was rated at 1,000 barrels a day. Well No. 4 on this tract was rated at 2,000 barrels a day.

Goose Creek and Humble, the two largest producing pools of the coastal Texas fields, continued to furnish large producing wells throughout the year. At Goose Creek a number of wells with initial capacities of 1,000 to 10,000 barrels a day were reported. The E. F. Simms No. 6 well, on the Sweet tract, was probably the largest and was rated at more than 10,000 barrels a day. The effect of these large wells at Goose Creek was to increase its production materially, making it the largest producing district of the field.

Despite the bringing in of several new wells rated at from 1,000 to 6,000 barrels initial daily capacity, the Humble pool showed a slight decrease in production for the year.

An extension of the Saratoga pool was opened up by the completion of a 3,000-barrel well by the Empire Gas & Fuel Co., at a depth of 2,045 feet, a quarter of a mile east of previous producing territory. Later two 12,000-barrel wells were reported from this eastern extension and also several failures.

Southern Texas.

Increased drilling activity was reported from Bexar and Duval counties. Near Noleda in Duval County, 90 miles south of San Antonio, a number of wells 200 to 500 feet in depth have been producing for several years.

PETROLEUM PRODUCED.

Petroleum produced in Texas, 1909–1918, in barrels.

Year.	Northern and central Texas.								
	Corsicana.	Powell.	Petrolia (Henrietta).	Marion County.	Wichita County.	Moran.	Thrall.	Strawn.	Brownwood.
1909	180,764	383,137	113,485	.....	.....	.....	.....	.....	.....
1910	137,331	450,188	126,531	251,717	.....	.....	.....	.....	.....
1911	128,526	373,055	168,965	677,689	899,579	.....	.....	.....	.....
1912	233,282	251,240	197,421	362,870	4,227,104	.....	.....	.....	.....
1913	158,830	282,476	344,868	262,392	8,131,624	.....	.....	.....	.....
1914	133,811	282,279	550,585	180,584	8,227,968	68,191	.....	.....	.....
1915	143,275	237,410	349,857	123,464	5,833,951	109,016	613,182	50,498	.....
1916	135,263	215,729	302,145	64,971	7,837,386	135,608	432,695	175,147	.....
1917	131,828	196,855	282,420	57,952	9,541,636	68,118	176,887	340,950	6,041
1918	117,577	195,207	245,753	48,041	11,527,034	47,777	137,159	278,634	222,778

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Petroleum produced by Texas, 1909–1918, in barrels—Continued.

Year.	Northern and central Texas—Contd.				Coastal Texas.				
	Ranger.	Breckenridge.	Other.	Total.	Spindletop.	Saratoga.	Sourlake.	Matagorda County.	Batson.
1909	.....	.....	4,554	681,940	1,388,107	1,183,559	1,703,798	29,103	1,206,214
1910	.....	.....	3,636	969,403	1,182,436	1,024,348	1,518,723	455,999	1,113,767
1911	.....	.....	3,379	2,251,193	905,939	925,777	1,364,880	561,826	1,023,493
1912	.....	.....	3,590	5,275,507	822,916	1,116,655	1,175,108	613,292	844,563
1913	.....	.....	4,062	9,184,252	716,374	937,720	1,348,053	294,553	741,350
1914	.....	.....	7,704	9,451,122	580,130	889,743	5,209,208	164,192	775,804
1915	.....	.....	12,900	7,473,553	388,286	864,266	4,114,622	137,841	703,686
1916	.....	.....	4,061	9,303,005	340,441	781,128	4,923,332	158,338	744,915
1917	29,055	36,219	32,685	10,900,646	380,039	682,797	4,763,004	128,011	692,417
1918	3,784,434	598,437	77,781	17,280,612	557,128	722,353	3,407,096	64,616	634,736

Year.	Coastal Texas—Continued.								State total.
	Humble.	Dayton.	Goose Creek.	Orange County	Damon Mound.	Hull-Raywood.	Other.	Total.	
1909	3,237,060	17,647	.....	.....	.....	.....	87,039	8,852,527	9,534,467
1910	2,495,511	9,582	.....	.....	.....	.....	129,497	7,929,863	8,899,266
1911	2,426,220	4,344	.....	.....	.....	.....	2,800	7,275,281	9,526,474
1912	1,829,923	12,151	43,898	.....	.....	.....	1,044	6,459,550	11,735,057
1913	1,504,880	13,329	249,641	17,706	.....	.....	1,620	5,825,226	15,009,478
1914	2,799,458	18,791	134,748	43,208	.....	.....	1,780	10,617,062	20,068,184
1915	11,061,802	10,378	119,336	21,697	.....	.....	47,254	17,469,148	24,942,701
1916	10,925,805	8,571	397,391	17,758	.....	.....	43,921	18,341,600	27,644,605
1917	7,389,831	9,995	7,300,279	7,023	[a] 124,325	.....	34,920	21,512,641	32,413,287
1918	6,555,173	8,526	8,943,635	.....	[a] 283,527	244,887	47,142	21,469,419	38,750,031

[a] Including West Columbia.

Petroleum produced in Texas, 1909–1918.

Year.	Northern Texas.		Coastal Texas.		Total.	
	Quantity (barrels).	Value.	Quantity (barrels).	Value.	Quantity (barrels).	Value.
1909	681,940	$393,732	8,852,527	$6,399,318	9,534,467	$6,793,050
1910	969,403	505,396	7,929,863	6,100,359	8,899,266	6,605,755
1911	2,251,193	1,213,960	7,275,281	5,340,592	9,526,474	6,554,552
1912	5,275,507	4,112,815	6,459,550	4,739,898	11,735,057	8,852,713
1913	9,184,252	9,125,185	5,825,226	5,550,408	15,009,478	14,675,593
1914	9,451,122	7,778,455	10,617,062	7,164,393	20,068,184	14,942,848
1915	7,473,553	4,656,934	17,469,148	8,369,991	24,942,701	13,026,925
1916	9,303,005	11,834,973	18,341,600	13,925,362	27,644,605	25,760,335
1917	10,900,646	19,952,665	21,512,641	22,938,890	32,413,287	42,891,555
1918	17,280,612	38,313,019	21,469,419	36,554,518	38,750,031	74,867,537

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Petroleum produced in Texas in 1917 and 1918, by districts, with increase or decrease.

District.	1917			1918			Increase or decrease.	
	Quantity (barrels).	Value.	Average price per barrel.	Quantity (barrels).	Value.	Average price per barrel.	Barrels.	Per cent.
Northern Texas:								
Breckenridge	36,219	$72,438	$2.000	598,437	$1,339,844	$2.239	+ 562,218	+ 1552.27
Brownwood	6,041	12,082	2.000	222,778	502,379	2.255	+ 216,737	+ 3587.77
Corsicana	131,828	233,591	1.772	117,577	258,858	2.202	− 14,251	− 10.81
Marion County	57,952	108,284	1.869	48,041	105,613	2.198	− 9,911	− 17.10
Moran	68,118	123,641	1.815	47,777	103,535	2.167	− 20,341	− 29.86
Petrolia	282,420	517,025	1.831	245,753	538,530	2.191	− 36,667	− 12.98
Powell	196,855	181,985	.924	195,207	244,244	1.251	− 1,648	− .84
Ranger	29,055	66,552	2.291	3,784,434	8,541,571	2.257	+3,755,379	+12,925.07
Strawn	340,950	695,925	2.041	278,634	621,639	2.231	− 62,316	− 18.28
Thrall	176,887	351,542	1.987	137,159	326,534	2.381	− 39,728	− 22.46
Wichita County	9,541,636	17,541,605	1.838	11,527,034	25,562,050	2.218	+1,985,398	+ 20.81
Other	32,685	47,996	1.468	77,781	168,222	2.163	+ 45,096	+ 137.97
	10,900,646	19,952,665	1.830	17,289,612	38,313,019	2.217	+6,379,966	+ 58.53
Coastal Texas:								
Batson	692,417	806,282	1.164	634,736	1,089,487	1.716	− 57,681	− 9.09
Damon Mound / West Columbia	124,325	111,892	.900	283,527	287,915	1.015	+ 159,202	+ 128.05
Dayton	9,995	10,282	1.028	8,526	15,347	1.800	− 1,469	− 17.23
Goose Creek	7,300,279	8,264,791	1.132	8,943,635	14,730,998	1.647	+1,643,356	+ 22.51
Hull / Raywood	.....	.....	.....	244,887	440,797	1.800	+ 244,887	.....
Humble	7,389,831	7,474,602	1.011	6,555,173	11,739,380	1.791	− 834,658	− 12.73
Matagorda County	128,011	128,239	1.002	64,616	114,416	1.770	− 63,395	− 49.52
Orange County	7,023	5,474	.780	.....	.....	.....	− 7,023	− 100.00
Saratoga	682,797	643,064	.942	722,353	1,235,589	1.711	+ 39,556	+ 5.79
Sourlake	4,763,004	4,944,032	1.038	3,407,096	5,849,624	1.717	−1,355,308	− 28.45
Spindletop	380,039	506,752	1.333	557,128	961,439	1.726	+ 177,089	+ 46.60
Other	34,920	43,480	1.245	47,142	89,526	1.899	+ 12,222	+ 35.00
	21,512,641	22,938,800	1.066	21,469,419	36,554,518	1.703	− 43,222	− .20
Total Texas	32,413,287	42,891,555	1.323	38,750,031	74,867,537	1.932	+6,336,744	+ 19.55

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Petroleum produced in Texas in 1917 and 1918, in barrels.

1917.

Month.	Northern Texas.												
	Breckenridge.	Brownwood.	Corsicana.	Marion County.	Moran.	Petrolia (Henrietta).	Powell.	Ranger.	Strawn.	Thrall.	Wichita County.	Other.[a]	Total.
January	.....	.....	9,031	5,962	6,516	18,762	16,605	.....	21,800	18,507	716,247	283	813,713
February	.....	.....	8,832	5,884	4,402	16,848	16,397	.....	30,819	13,576	641,503	283	738,544
March	.....	.....	9,479	6,279	6,757	25,595	17,558	.....	25,973	19,443	714,129	283	825,506
April	.....	.....	20,667	5,748	5,864	24,740	17,309	.....	30,030	14,462	693,325	1,002	813,207
May	.....	.....	9,861	5,961	6,906	25,529	18,782	.....	43,364	15,212	742,329	750	868,594
June	.....	.....	9,074	5,478	5,843	21,298	15,852	.....	48,121	13,896	765,725	656	885,933
July	.....	.....	9,976	5,392	5,484	23,019	15,965	.....	43,092	13,501	819,290	2,743	938,462
August	.....	.....	9,611	4,911	5,027	26,035	16,948	.....	35,467	15,162	891,466	3,049	1,007,676
September	12,705	.....	9,887	5,084	4,435	25,593	15,040	.....	24,667	13,920	878,619	5,549	995,499
October	8,165	708	16,508	4,382	6,504	26,266	16,089	.....	18,014	14,047	884,452	7,751	1,002,886
November	7,734	2,136	9,321	661	5,449	24,529	15,640	10,737	10,866	13,074	892,638	5,644	998,429
December	7,615	3,197	9,581	2,310	4,931	24,206	14,610	18,318	8,737	12,087	901,913	4,692	1,012,197
	36,219	6,041	131,828	57,952	68,118	282,420	196,855	29,055	340,950	176,887	9,541,636	32,685	10,900,646

Month.	Coastal Texas.											State total.
	Batson.	Damon Mound.	Dayton.	Goose Creek.	Humble.	Matagorda County.[b]	Orange County.	Saratoga.	Sourlake.	Spindletop.	Other.[c]	Total.	
January	70,656	.....	687	195,515	685,043	9,234	811	64,646	621,766	25,227	3,023	1,676,608	2,490,321
February	60,584	.....	433	305,330	651,189	9,220	384	58,625	467,140	25,719	2,741	1,581,365	2,319,909
March	62,495	250	1,473	361,022	706,597	13,519	510	61,636	497,229	28,600	2,391	1,735,722	2,561,228
April	60,907	250	489	633,132	662,860	13,209	702	65,188	414,123	27,846	2,936	1,881,642	2,694,849
May	63,601	250	985	507,673	658,276	12,084	805	69,263	414,107	29,035	2,998	1,759,077	2,627,671
June	59,018	250	929	631,077	564,330	13,383	788	64,852	410,350	31,727	2,818	1,779,522	2,665,455
July	63,798	750	952	881,340	583,607	14,392	872	67,209	390,644	32,788	2,855	2,039,207	2,977,609
August	62,122	750	769	903,222	582,571	11,819	859	64,016	382,669	29,687	2,997	2,041,481	3,049,157
September	59,125	750	407	915,955	616,523	9,244	764	61,729	330,366	32,141	2,770	2,029,774	3,025,273
October	58,151	22,932	1,039	709,043	639,115	7,717	528	61,963	329,987	38,086	3,095	1,872,256	2,875,142
November	31,671	43,737	1,043	502,047	545,074	5,362	.....	16,246	226,831	40,334	3,023	1,415,368	2,413,797
December	40,289	54,406	789	754,323	494,646	8,828	.....	27,424	277,792	38,849	3,273	1,700,619	2,712,816
	692,417	124,325	9,995	7,300,279	7,389,831	128,011	7,023	682,797	4,763,004	380,039	34,920	21,512,641	32,413,287

[a] Includes Archer, Coleman, Jack, and McLennan counties and Millsap pool.
[b] Markham and Big Hill.
[c] Includes Bexar, Duval, McMullen, and Washington counties.

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Month.	Northern Texas.												Total.
	Breckenridge.	Brownwood.	Corsicana.	Marion County.	Moran.	Petrolia (Henrietta).	Powell.	Ranger.	Strawn.	Thrall.	Wichita[a] County.	Other.[b]	
January	8,894	3,628	8,356	3,487	4,997	22,514	14,645	52,451	12,224	13,334	885,570	3,805	1,033,895
February	9,308	4,754	9,146	3,632	4,609	21,237	15,938	1,566	34,653	12,927	812,699	1,387	931,856
March	14,591	10,916	9,432	4,334	4,367	23,437	16,604	20,339	40,314	12,441	851,883	3,703	1,012,361
April	24,741	13,811	8,495	4,514	4,168	21,702	15,466	72,689	29,465	14,706	821,990	7,506	1,039,313
May	21,174	13,385	9,601	4,030	4,633	22,209	20,127	59,838	17,584	12,480	883,595	9,982	1,078,638
June	18,084	12,287	8,873	4,055	3,278	19,735	16,312	122,299	12,521	9,624	878,548	8,587	1,114,203
July	35,942	35,124	9,566	4,499	3,224	18,477	17,195	246,914	3,359	12,006	954,973	7,711	1,348,990
August	41,185	36,139	9,310	4,276	3,828	19,750	17,674	442,067	31,142	9,940	948,290	8,422	1,572,023
September	67,293	27,471	8,394	3,883	3,358	17,737	15,119	458,115	18,899	10,627	1,007,357	5,509	1,643,762
October	109,923	24,910	8,888	3,766	3,648	21,002	17,109	461,127	19,275	9,589	1,065,272	9,611	1,754,180
November	111,203	22,472	19,750	3,527	3,244	19,118	14,557	657,642	27,369	9,708	1,153,362	6,871	2,048,823
December	136,049	17,881	7,766	4,038	4,423	18,835	14,461	1,189,387	31,829	9,717	1,263,495	4,687	2,702,568
	598,437	222,778	117,577	48,041	47,777	245,753	195,207	3,784,434	278,634	137,159	11,527,034	77,781	17,280,612

Month.	Coastal Texas.											State Total.
	Batson.	Damon Mound.[c]	Dayton.	Goose Creek.	Humble.	Hull and Raywood.	Matagorda County.[d]	Saratoga.	Sourlake.	Spindletop.	Other.[e]	Total.	
January	48,225	47,468	613	665,112	555,647	.....	8,023	48,070	279,999	39,197	2,808	1,695,162	2,729,057
February	45,742	29,863	335	596,559	527,138	.....	7,088	46,455	267,461	37,891	2,944	1,561,476	2,493,332
March	52,026	28,454	390	778,060	574,383	.....	7,612	50,374	309,940	45,317	3,216	1,849,772	2,862,133
April	51,303	26,811	1,573	760,323	522,860	.....	5,838	51,289	294,104	50,383	3,456	1,767,940	2,807,253
May	53,560	27,170	406	842,871	619,806	.....	4,955	70,919	314,767	53,316	2,884	1,990,654	3,069,292
June	51,227	12,355	1,158	869,456	704,482	.....	4,537	70,644	289,677	51,462	3,694	2,058,692	3,172,895
July	56,924	20,486	520	809,647	680,728	1,494	4,939	74,701	302,878	51,875	3,916	2,008,108	3,357,098
August	62,519	13,702	414	761,957	510,768	23,982	5,207	59,856	286,632	52,830	3,676	1,781,543	3,353,566
September	53,249	16,050	450	832,414	534,385	53,124	4,534	67,135	270,054	43,916	4,748	1,880,059	3,523,821
October	58,811	17,513	913	791,258	467,296	58,134	3,897	66,703	279,944	48,369	4,530	1,797,368	3,551,548
November	48,230	19,349	1,301	604,591	437,306	63,010	3,398	56,898	252,692	42,026	5,700	1,534,501	3,583,324
December	52,920	24,306	453	631,387	420,374	45,143	4,588	59,309	259,548	40,546	5,570	1,544,144	4,246,712
	634,736	283,527	8,526	8,943,635	6,555,173	244,887	64,616	722,353	3,407,696	557,128	47,142	21,469,419	38,750,031

[a] Includes Wilbarger County.
[b] Archer, Coleman, McLennan, Panola, and Shelby counties.
[c] Includes West Columbia.
[d] Markham and Big Hill.
[e] Bexar, Chambers, Duval, McMullen, and Washington counties.

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SUMMARY OF WELLS DRILLED.

The statistics of field operations presented in the following tables are compiled from trade-journal sources, and differ somewhat from those on page 989, obtained from reports received directly from the oil producers:

Wells completed in northern and central Texas, 1914–1918.

District.	Oil.					Dry.					Total completed.[a]				
	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918
Archer County			2	10	2			1	41	2			3	51	4
Brown County				3	86	1			1	16	2			4	102
Coleman County			5	3	9			1	2	2			7	6	14
Comanche County					2										2
Corsicana[b]	10	1	2		1	5				1	15	1	2		2
Eastland County				1	62	2	1			21	3	1		2	88
Jack County		2	1	1				2	1			2	3	2	
Marion County	8	13	7		2	2	5	9	1	2	10	18	16	1	4
Moran	3	9	2			3	12	4	1	4	12	21	6	1	4
Panola County			1	1	1			1	5	4			3	6	6
Parker County				1					2	3				3	3
Petrolia[c]	80	4	6	8	3	32	1	3	9	6	126	8	17	20	11
Shelby County				1	4	1		1	2		1		2	4	4
Stephens County			2	4	24			1	9	13			4	14	46
Strawn[d]		40	51	65	4		35	27	22	7		89	98	100	11
Thrall[e]		112	49				103	15				216	64		
Wichita County	394	124	372	631	691	169	29	65	184	203	567	156	441	816	894
Wilbarger County		1										1	1		
Young County		1							1	2		1		1	2
Miscellaneous	2					7	12	16	11	18	9	14	18	14	19
Coastal and southern Texas	497	307	500	729	891	222	198	146	292	304	745	528	685	1,045	1,219
	323	306	647	770	838	129	230	354	517	389	463	541	1,028	1,336	1,249
Total Texas	820	613	1,147	1,499	1,729	351	428	500	809	693	1,208	1,069	1,713	2,381	2,468

[a] Including gas wells.
[b] Including Powell.
[c] Including Henrietta.
[d] Including other tests in Palo Pinto County.
[e] Including other tests in Williamson County.

Oil wells and dry holes drilled in northern and central Texas in 1918.

District.	January.		February.		March.		April.		May.		June.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Archer County												2
Brown County					7	2	8	1	29	6	22	
Coleman County		1			1		1				4	
Comanche County												
Corsicana[a]									1			
Eastland County		1	1		2				3	1	4	
Marion County			1							1		
Moran						1						3
Panola County								1				
Parker County		1								2		
Petrolia[b]			2							1		3
Shelby County							1					
Stephens County		2			2	1	2		3			2
Strawn	1	2				1	1		1	2		
Wichita County	41	11	51	14	112	13	81	15	75	34	75	19
Wilbarger County												
Young County		1										
Miscellaneous		1				4				2		3
Coastal and southern Texas	42	20	55	14	124	22	94	17	112	49	105	32
	43	28	53	28	72	36	72	29	102	34	85	37
Total Texas	85	48	108	42	196	58	166	46	214	83	190	69

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Oil wells and dry holes drilled in northern and central Texas in 1918—Continued.

District.	July.		August.		September.		October.		November.		December.		Total.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Archer County							1		1				2	2
Brown County	20					1		4				1	86	16
Coleman County						1	1		2				9	2
Comanche County					1						1		2	
Corsicana[a]		1											1	1
Eastland County	7	8	5	2	10	2	5	3	9	2	16	7	62	21
Marion County				1			1						2	2
Moran														4
Panola County		2		1							1		1	4
Parker County														3
Petrolia[b]				1				1	1				3	6
Shelby County	2		1										4	
Stephens County	2	1			5	2	2		7	1	1	4	24	13
Strawn		1				1			1				4	7
Wichita County Wilbarger County	59	30	30	22	27	7	36	13	45	11	59	15	691	203
Young County		1												2
Miscellaneous		2		1		2		2		1				18
Coastal and southern Texas	90	41	36	28	43	16	46	23	66	15	78	27	891	304
	79	33	81	40	77	33	56	26	66	27	52	38	838	389
Total Texas	169	74	117	68	120	49	102	49	132	42	130	65	1,729	693

[a] Including Powell. [b] Including Henrietta.

Wells completed in northern and central Texas, 1914–1918.

Month.	Oil.					Dry.					Total completed.[a]				
	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918
January	64	14	34	37	42	24	6	12	8	20	89	20	49	51	62
February	49	22	44	46	55	23	9	8	16	14	74	31	55	65	71
March	95	20	37	48	124	39	7	16	24	22	138	28	59	73	151
April	79	34	54	62	94	22	17	11	20	16	106	53	69	82	111
May	46	37	56	75	112	26	28	13	23	49	73	66	75	101	163
June	44	30	62	90	105	15	31	14	29	32	61	63	79	121	139
July	23	12	41	59	90	18	13	17	26	41	42	29	60	86	131
August	29	29	24	56	36	11	22	9	22	28	42	52	37	81	66
September	16	23	40	65	43	6	15	17	36	16	25	39	59	102	60
October	20	19	31	68	46	18	16	12	32	23	40	37	44	103	72
November	22	33	38	75	66	12	16	8	37	16	36	55	47	113	86
December	10	34	39	48	78	8	18	9	19	27	19	55	52	67	107
	497	307	500	729	891	222	198	146	292	304	745	528	685	1,045	1,219

[a] Including gas wells.

Initial daily production of new wells completed in northern and central Texas in 1918, in barrels.

District.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Archer County										50	40		90
Brown County			137	85	420	320	295						1,257
Coleman County			100	45		35				25	50		255
Comanche County									600			1,000	1,600
Corsicana[a]					5								5
Eastland County		20	1,950		535	2,595	7,940	6,420	8,950	4,235	5,425	24,510	62,580
Marion County		15								65			80
Panola County												10	10
Petrolia[b]		20									15		35
Shelby County				30			50	15					95
Stephens County			300	450	205		940		4,100	2,000	1,425	750	10,170
Strawn	35			4	5						100		144
Wichita County Wilbarger County	1,844	1,626	6,268	3,479	2,680	2,314	2,910	7,270	11,279	5,605	11,130	14,675	71,080
Coastal and southern Texas	1,879	1,681	8,755	4,093	3,850	5,264	12,135	13,705	24,929	11,980	18,185	40,945	147,401
	8,420	19,622	36,095	16,725	28,365	50,346	21,045	15,495	36,942	14,045	12,146	21,001	280,247
Total Texas	10,299	21,303	44,850	20,818	32,215	55,610	33,180	29,200	61,871	26,025	30,331	61,946	427,648

[a] Including Powell. [b] Including Henrietta.

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Total and average initial daily production of new wells in northern and central Texas, 1914–1918, by districts, in barrels.

District.	Total initial production.					Average per well.				
	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918
Archer County	.....	.....	60	690	90	.....	.....	30.0	69.0	45.0
Brown County	.....	.....	.....	80	1,257	.....	.....	.....	26.7	14.6
Coleman County	.....	.....	150	160	255	.....	.....	30.0	53.3	28.3
Comanche County	.....	.....	.....	.....	1,600	.....	.....	.....	.....	800.0
Corsicana[a]	23	2	20	.....	5	2.3	2.0	10.0	.....	5.0
Eastland County	.....	.....	.....	510	62,580	.....	.....	.....	510.0	1,009.4
Jack County	.....	15	2	20	.....	.....	7.5	2.0	20.0	.....
Marion County	390	1,445	735	.....	80	48.8	111.2	105.0	.....	40.0
Moran	690	995	40	.....	.....	210.0	110.6	20.0	.....	.....
Panola County	.....	.....	15	6	10	.....	.....	15.0	6.0	10.0
Parker County	.....	.....	.....	100	.....	.....	.....	.....	100.0	.....
Petrolia[b]	1,958	273	285	1,050	35	24.5	68.3	47.5	131.3	11.7
Shelby County	.....	.....	.....	25	95	.....	.....	.....	25.0	23.8
Stephens County	.....	.....	105	400	10,170	.....	.....	52.5	100.0	423.8
Strawn	.....	1,245	2,010	1,799	144	.....	31.1	39.4	27.7	36.0
Thrall	.....	43,170	2,053	.....	.....	.....	385.4	41.9	.....	.....
Wichita County	21,917	5,488	44,253	46,313	71,080	55.6	44.3	119.0	73.4	102.9
Wilbarger County	.....	10	.....	.....		.....	10.0	.....	.....	
Young County	.....	20	.....	.....	.....	.....	20.0	.....	.....	.....
Other	25	.....	.....	.....	.....	12.5	.....	.....	.....	.....
Coastal and southern Texas	25,003 160,695	52,663 292,541	49,728 388,422	51,153 445,263	147,401 280,247	50.3 497.5	171.5 956.0	99.5 600.3	70.2 578.3	165.4 334.4
Total Texas	185,698	345,204	438,150	496,416	427,648	226.4	563.1	382.0	331.2	247.3

[a] Including Powell. [b] Including Henrietta.

Total initial daily production of new wells in northern and central Texas, 1914–1918, by months; in barrels.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.	Monthly average.
1914	5,401	4,217	3,785	2,731	2,306	2,229	965	1,138	1,184	261	622	164	25,003	2,084
1915	507	1,300	6,250	9,558	11,365	9,940	4,455	3,655	1,720	785	1,748	1,380	52,663	4,389
1916	2,540	2,784	3,119	4,168	4,809	10,841	9,941	1,927	2,336	1,809	4,303	1,151	49,728	4,144
1917	3,864	2,861	2,719	1,629	4,552	5,903	3,835	5,322	3,055	8,048	4,544	4,821	51,153	4,263
1918	1,879	1,681	8,755	4,093	3,850	5,264	12,135	13,705	24,929	11,980	18,185	40,945	147,401	12,283

Wells completed in coastal and southern Texas, 1914–1918.

District.	Oil.					Dry.					Total completed.[a]				
	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918
Atascosa County	.....	.....	.....	.....	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	2
Batson	51	36	75	41	53	9	7	16	13	16	60	43	92	55	71
Bexar County	.....	5	6	6	11	.....	1	4	4	5	.....	6	10	10	16
Brazoria County	.....	.....	2	.....	.....	.....	.....	14	7	15	.....	.....	17	8	15
Burleson County	.....	.....	.....	1	.....	.....	.....	1	2	.....	.....	.....	1	3	.....
Chambers County	.....	.....	1	3	2	.....	2	4	6	1	.....	2	5	9	3
Damon Mound	.....	.....	.....	11	24	.....	.....	.....	24	24	.....	.....	.....	35	48
Dayton[b]	2	1	6	3	5	.....	7	13	12	12	2	8	19	15	17
Duval County	.....	3	6	5	15	.....	.....	1	7	4	.....	3	8	12	19
Goose Creek	34	6	42	274	209	10	5	15	141	66	44	11	60	443	281
Hull	.....	.....	.....	.....	6	.....	.....	.....	.....	5	.....	.....	.....	.....	11
Humble	46	106	305	217	264	33	69	150	129	113	80	176	471	354	383
Matagorda County	1	8	12	12	1	.....	.....	11	13	11	4	8	23	28	12
Nacogdoches County	.....	.....	1	.....	1	.....	.....	1	.....	.....	.....	.....	2	.....	1
Orange County	3	.....	.....	1	.....	5	5	3	3	.....	8	5	3	4	.....
Saratoga	17	34	55	35	46	4	11	12	12	23	21	45	67	49	69
Sourlake	140	93	114	132	98	44	52	32	46	24	184	146	146	178	125
Spindletop	24	11	22	28	94	7	3	13	18	17	32	14	35	46	111
Washington County	.....	2	.....	.....	.....	.....	1	4	1	.....	.....	4	4	1	.....
West Columbia	.....	.....	.....	1	12	.....	.....	.....	4	3	.....	.....	.....	5	19
Wilson County	.....	1	.....	.....	.....	.....	1	.....	.....	.....	.....	2	.....	.....	.....
Miscellaneous	5	.....	.....	.....	.....	17	66	60	75	50	28	68	65	80	51
Central and northern Texas	323 497	306 307	647 500	770 729	838 891	129 222	230 198	354 146	517 292	389 304	463 745	541 528	1,028 685	1,336 1,045	1,249 1,219
Total Texas	820	613	1,147	1,499	1,729	351	428	500	809	693	1,208	1,069	1,713	2,381	2,468

[a] Including gas wells. [b] Including miscellaneous tests in Liberty County.

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Oil wells and dry holes drilled in coastal and southern Texas in 1918.

District.	January.		February.		March.		April.		May.		June.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Atascosa County												
Batson	2		3	1	4		5		5	3	2	3
Bexar County			2								1	2
Brazoria County		1		2		3				1		2
Chambers County												
Damon Mound	1	2	2	2	4	7	5	2	2		2	
Dayton[a]		2		2		1		2		1		1
Duval County		1			2	1	2		3	1	3	
Goose Creek	9	3	14	3	24	4	15	10	23	2	23	6
Hull												
Humble	17	14	20	8	20	6	27	9	32	10	22	17
Matagorda County						4		1		1		
Nacogdoches County	1											
Saratoga	1			2	3	1	3		7		4	2
Sourlake	4	1	6	1	8	4	6		14	2	11	3
Spindletop	7	1	6		7	1	8	1	15	3	16	1
West Columbia	1			1			1	1	1		1	
Miscellaneous		3		6		4		3		10		
	43	28	53	28	72	36	72	29	102	34	85	37
Central and northern Texas	42	20	55	14	124	22	94	17	112	49	105	32
Total Texas	85	48	108	42	196	58	166	46	214	83	190	69

District.	July.		August.		September.		October.		November.		December.		Total.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Atascosa County					2								2	
Batson	9	3	6		5	1	3	1	4	2	5	2	53	16
Bexar County				1	1		1		2		4	2	11	5
Brazoria County				3		1		2						15
Chambers County					1					1	1		2	1
Damon Mound	1	1	1		2	6		2	3	2	1		24	24
Dayton[c]				1						1		1		12
Duval County			3	1	2								15	3
Goose Creek	19	6	19	10	24	5	12	3	13		14	14	209	66
Hull	1	1	1	1	1		1	2	1		1	1	6	5
Humble	24	10	28	8	18	7	21	10	25	7	10	7	264	113
Matagorda County		2			1	2				1			1	11
Nacogdoches County													1	
Saratoga	6	3	3	2	7	5	5		3	4	4	4	46	23
Sourlake	9		10	4	8	2	7	2	8	2	7	3	98	24
Spindletop	8	3	9	2	5	2	5		4	2	4	1	94	17
West Columbia	2		1				1		3		1	1	12	3
Miscellaneous		4		7		2		4		5		2		50
	79	33	81	40	77	33	56	26	66	27	52	38	838	389
Central and northern Texas	90	41	36	28	43	16	46	23	66	15	78	27	891	304
Total Texas	169	74	117	68	120	49	102	49	132	42	130	65	1,729	693

[a] Including miscellaneous tests in Liberty County.

Wells completed in coastal and southern Texas, 1914–1918.

Month.	Oil.					Dry.					Total completed.[a]				
	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918
January	38	22	41	48	43	3	11	27	26	28	42	33	73	83	72
February	18	25	47	53	53	4	4	32	35	28	24	29	81	93	81
March	22	17	66	78	72	7	15	25	28	36	29	32	91	112	109
April	20	15	74	73	72	18	18	29	37	29	39	33	105	113	104
May	37	24	90	88	102	8	13	48	68	34	47	37	143	160	139
June	27	30	57	83	85	9	32	36	64	37	36	62	96	155	125
July	37	25	56	83	79	18	34	33	47	33	56	60	91	134	113
August	32	26	49	59	81	20	17	29	40	40	54	44	80	99	124
September	21	32	39	62	77	8	23	25	71	33	30	55	66	136	112
October	23	20	37	74	56	16	11	15	47	26	39	31	52	125	85
November	26	37	39	35	66	13	28	26	24	27	40	66	68	61	94
December	22	33	52	34	52	5	24	29	30	38	27	59	82	65	91
	323	306	647	770	838	129	230	354	517	389	463	541	1,028	1,336	1,249

[a] Including gas wells.

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Initial daily production of new wells completed in coastal and southern Texas in 1918, in barrels.

District.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Atascosa County									90				90
Batson	55	95	135	60	60	156	605	2,170	475	125	40	76	4,052
Bexar County		17				10			17	10	20	30	104
Chambers County									40			200	240
Damon Mound	1,500	450	435	1,400	500	225	250	20	80		275	300	5,435
Duval County			10	20	35	20		35	15				135
Goose Creek	2,900	10,250	25,315	10,965	22,165	22,875	11,705	6,600	22,320	3,575	5,650	4,950	149,270
Hull							1,000	2,000	3,000	700	1,500	2,500	10,700
Humble	1,355	8,055	5,990	1,125	1,090	4,435	4,045	1,215	7,010	8,230	3,416	5,340	51,306
Matagorda County									10				10
Nacogdoches County	10												10
Saratoga	20		3,035	40	2,525	21,100	1,005	425	2,805	420	100	370	31,845
Sourlake	1,805	240	615	1,810	575	770	330	2,205	805	645	595	155	10,550
Spindletop	575	515	560	1,155	1,340	720	605	625	275	140	125	80	6,715
West Columbia	200			150	75	35	1,500	200		200	425	7,000	9,785
Central and northern Texas	8,420	19,622	36,095	16,725	28,365	50,346	21,045	15,495	36,942	14,045	12,146	21,001	280,247
	1,879	1,681	8,755	4,093	3,850	5,264	12,135	13,705	24,929	11,980	18,185	40,945	147,401
Total Texas	10,299	21,303	44,850	20,818	32,215	55,610	33,180	29,200	61,871	26,025	30,331	61,946	427,648

Total and average initial daily production of new wells in coastal and southern Texas, 1914–1918, by districts, in barrels.

District.	Total initial production.					Average per well.				
	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918
Atascosa County					90					45.0
Batson	2,191	931	11,479	2,396	4,052	43.0	25.9	153.1	58.4	76.5
Bexar County		185	390	65	104		37.0	65.0	10.8	9.5
Brazoria County			14					7.0		
Burleson County				5					5.0	
Chambers County			10	85	240			10.0	28.3	120.0
Damon Mound				14,600	5,435				1,327.3	226.5
Dayton	400	20	134	25		200.0	20.0	22.3	8.3	
Duval County		80	385	65	135		26.7	64.2	13.0	9.0
Goose Creek	2,375	710	23,250	123,495	149,270	69.9	118.3	553.6	1,180.6	714.2
Hull					10,700					1,783.3
Humble	22,842	266,830	276,355	56,057	51,306	496.6	2,517.3	906.1	258.3	194.3
Matagorda County	25	2,375	5,520	795	10	25.0	296.8	460.0	66.3	10.0
Nacogdoches County			10		10			10.0		10.0
Orange County	350			25		116.7			25.0	
Saratoga	900	2,510	2,098	2,590	31,845	52.9	73.8	38.1	74.0	692.3
Sourlake	130,341	18,695	67,855	43,453	10,550	931.0	201.0	595.2	329.2	107.7
Spindletop	1,191	160	922	1,596	6,715	49.6	14.5	41.9	57.0	71.4
Washington County		40					20.0			
West Columbia				12	9,785				12.0	815.4
Wilson County		5					5.0			
Miscellaneous	80					16.0				
Central and northern Texas	160,695	292,541	388,422	445,283	280,247	497.5	956.0	600.3	578.3	334.4
	25,003	52,663	49,728	51,153	147,401	50.3	171.5	99.5	70.2	165.4
Total Texas	185,698	345,204	438,150	496,416	427,648	226.4	563.1	382.0	331.2	247.3

Total initial daily production of new wells in coastal and southern Texas, 1914–1918, by months, in barrels.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.	Monthly average.
1914	5,026	3,696	20,075	25,249	12,816	16,907	15,923	12,823	12,773	12,320	14,172	8,915	160,695	13,391
1915	15,180	14,458	3,385	3,300	11,220	12,640	13,475	13,880	36,133	61,030	88,100	19,740	292,541	24,378
1916	49,515	55,732	60,950	24,008	56,020	36,580	14,149	10,834	11,970	23,425	12,580	32,650	388,422	32,369
1917	33,660	40,325	64,730	37,396	36,410	50,508	32,040	55,605	34,582	30,473	14,157	15,377	445,263	37,105
1918	8,420	19,622	36,095	16,725	28,365	50,346	21,045	15,495	36,942	14,045	12,146	21,001	280,247	23,354

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LOUISIANA.

GENERAL STATEMENT.

Production of petroleum in Louisiana in 1918 was 16,042,600 barrels, an increase of 4,650,399 barrels, or 41 per cent, as compared with the output in 1917. Increase in production is credited almost entirely to the intensive development in the Pine Island district in Caddo Parish. The development of the prolific Pine Island pool in northern Louisiana resulted in wildcat drilling over considerable territory. Production in northern Louisiana was 13,304,399, barrels as compared with only 8,561,963 barrels in 1917. Of this total Caddo Parish contributed 11,143,890 barrels.

The average price received at the wells for all grades of petroleum produced in Louisiana in 1918 was $1.716 a barrel and the market value of the entire output was $27,535,060, a gain of 12 cents in average market price, and of $10,310,458, or 60 per cent, in gross market value, compared with 1917. The average market price of the petroleum of the northern division increased from $1.64 a barrel in 1917 to $1.73 a barrel in 1918, a net gain of 9 cents, or 5 per cent, and the market value of the output in 1918 exceeded that of the output in 1917 by $8,959,827, or about 64 per cent. The average market price of the oil produced in the coastal division increased from $1.113 a barrel in 1917 to $1.643 a barrel in 1918, a net gain of 53 cents, or 48 per cent, and the market value of the output exceeded that of the output in 1917 by $1,350,631, or 43 per cent.

DEVELOPMENT.

The increase in price of petroleum and the discovery of the rich Pine Island pool late in 1917 resulted in a marked increase in drilling activity in Louisiana, and 712 wells were drilled in 1918 primarily for petroleum, as compared with 634 in 1917. Of the total drilled in 1918, 506 were rated as oil wells with an average initial output of 410.7 barrels a day, 58 produced gas only, and 148, or 21 per cent, were dry holes. The success of operations in Louisiana was shown by the marked increase both in production and the average initial yield of new wells and also in the lower percentage of dry holes.

NORTHERN OR STRATUM DIVISION.

In northern Louisiana, which is included in the Mid-Continent field (pp. 1052–1059), 518 wells were completed in 1918, as compared with 456 completed in 1917. Of the wells drilled in 1918, 389 were rated as oil wells with an average initial yield of 439.9 barrels a day. This average initial yield was more than twice as great as the corresponding rate in 1917.

The feature of the year was the activity in the Pine Island district. This district was discovered in the spring of 1917, and development was well underway by the beginning of 1918. In September, 1918, the Old Settlers Oil Co. brought in a well which started flowing at the rate of 3,000 barrels a day on the Lynn lease, 2½ miles east of the original pool. Many good wells were completed and the field was gradually expanded until the proved productive territory at the end of the year covered an area of approximately 20 square miles. The crude oil from this well is reported to have a gravity of 26° to 32°

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Baumé and to have practically no gasoline content. At the end of the year the increasing production of the Pine Island district was far in excess of the pipe-line facilities. For this reason and also because of the cessation of war activities there was a great decrease in the demand for fuel oil, which resulted in the curtailment of the quantity of oil handled by the pipe-line companies from this field.

In November, 1918, it was reported that the Texas Co. had obtained a well rated at 1,000 barrels a day in the Dolet Lobe district on the border of Red River Parish, about 3 miles south of Gusher Bend. A number of tests made in this vicinity at the time of the Crichton boom resulted in dry holes. The well drilled by the Texas Co. was drilled to a greater depth. Several wells in this district were completed before the end of 1918. In the Monroe gas field in Ouachita Parish efforts were made to develop an oil field by deep drilling, but nothing of importance was discovered.

In Claiborne Parish near Homer, the Consolidated Progressive Oil Co. completed a well in September, 1918, on the Featherstone lease, in sec. 20, T. 21 N., R. 7 W. This well was in wildcat territory and opened up a new pool. This was the important find of the year in Louisiana not only in the opening up of a new pool but in giving promise for good oil territory over a large area where oil had not previously been discovered. In Bossier Parish interest was centered chiefly in the Elm Grove district. Tests for oil in the following parishes in northern Louisiana proved unsuccessful: La Salle, Morehouse, Natchitoches, Ouachita, Union, and Webster.

SOUTHERN OR SALT-DOME DIVISION.

The production of petroleum from the oil pools in southern Louisiana in 1918 was 2,738,201 barrels, a slight decrease from the record of 1917. The market value—$4,499,328—on the other hand was $1,350,631, or 43 per cent, greater than that of the output in 1917. Decrease in production is reported from Jennings, Anse la Butte, Edgerly, and New Iberia. An increase in production was reported from Vinton and from the old Welsh district, from which the Survey was unable to obtain record of any oil produced in 1917.

Increase in drilling activity in the Gulf Coast field resulted in the completion of 194 wells in 1918, as compared with 178 in 1917. Of these wells completed 117 were rated as oil wells, with an average initial yield of 273.6 barrels per day. The percentage of dry holes—39 per cent—was less than in 1917, but the average initial yield of new oil wells was also very much less. Increase in drilling activity was reported from Anse la Butte, Jennings, and Vinton. Edgerly, Jennings, and Vinton all showed a decrease in percentage of dry holes but at the same time a decrease in the average initial yield of new wells. In the New Iberia pool developed in 1917 results were discouraging inasmuch as 8 out of the 10 new wells reported were dry holes and new production amounted to only 85 barrels. The Welsh district was not successful with 4 completions, all of which were oil wells with an average yield of 93.7 barrels.

Drilling for oil in the following parishes was unsuccessful: Allen, Calcasieu, Cameron, Evangeline, Jefferson Davis (outside of the Welsh pool), Orleans, Plaquemines, St. Martin, Terrebonne, and Vermilion.

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PETROLEUM PRODUCED.

Petroleum produced in Louisiana, 1909–1918, in barrels.

Year.	Northern Louisiana.					
	Caddo.	De Soto.	Red River.	Sabine.	Bossier.	Total.
1909	1,028,818					1,028,818
1910	5,090,793					5,090,793
1911	6,995,828					6,995,828
1912	7,177,949					7,177,949
1913	9,781,560					9,781,560
1914	7,572,254	[a]3,834,593	401,622			11,808,469
1915	6,471,879	1,797,175	6,802,349	10,631		15,082,034
1916	5,463,682	1,657,216	4,691,323	9,421		11,821,642
1917	5,483,638	1,370,889	1,664,955	6,923	36,188	8,561,963
1918	11,143,890	1,065,847	1,045,263	4,261	45,138	13,304,399

Year.	Coasta lLouisiana.							State total.
	Jennings.	Welsh.	Anse la Butte.	Vinton.	Edgerly.	New Iberia.	Total.	
1909	1,966,614	26,169	37,930				2,030,713	3,059,531
1910	1,625,159	54,724	44,018	26,701			1,750,602	6,841,395
1911	1,180,177	27,901	62,411	2,454,103			3,724,592	10,720,420
1912	1,105,711	22,140	25,000	932,639			2,085,490	9,263,439
1913	790,648	31,144	6,612	1,888,864			2,717,268	12,498,828
1914	412,036	18,629	18,623	1,466,302	586,376		2,500,966	14,309,435
1915	434,815	16,451	20,982	1,234,227	1,403,030		3,109,505	18,191,539
1916	516,674	4,319	12,818	1,640,147	1,252,538		3,426,496	15,248,138
1917	399,469		4,900	1,595,366	805,609	24,894	2,830,238	11,392,201
1918	369,499	4,540	[b]3,000	1,839,083	512,458	9,621	2,738,201	16,042,600

[a] Includes Sabine. [b] Estimated.

Petroleum produced in Louisiana in 1917 and 1918, in barrels.

1917.

Month.	Northern Louisiana.					
	Bossier.	Caddo.	De Soto.	Red River.	Sabine.	Total.
January	1,530	399,338	114,833	210,790	996	727,487
February	1,738	341,717	100,775	167,487	324	612,041
March	2,597	432,311	130,580	172,349	312	738,149
April	2,207	449,764	131,477	159,794	1,186	744,428
May	3,379	507,107	144,306	162,303	336	817,431
June	3,338	480,258	188,167	140,374	327	812,464
July	4,051	578,249	134,143	138,145	337	854,925
August	3,165	588,640	117,980	137,383	639	847,807
September	3,845	573,234	105,863	131,633	332	814,907
October	3,737	576,367	109,409	129,682	604	819,799
November	3,283	208,715	26,809	40,974	327	280,108
December	3,318	347,938	66,547	74,041	573	492,417
	36,188	5,483,638	1,370,889	1,664,955	6,293	8,561,963

Month.	Coastal Louisiana.						State total.
	Anse la Butte.	Edgerly.	Jennings.	New Iberia.	Vinton.	Total.	
January	513	109,012	39,484		118,034	267,043	994,530
February	358	77,511	31,677		99,129	208,675	820,716
March	513	85,789	31,725		113,120	231,147	969,296
April	358	72,821	30,822		145,469	249,470	993,898
May	358	74,811	31,799		242,201	349,169	1,166,600
June	358	53,892	29,037	3,736	174,363	261,386	1,073,850
July	358	58,142	29,536	6,584	134,839	229,459	1,084,384
August	358	57,058	35,305	3,844	114,671	211,236	1,059,043
September	358	59,406	32,378	3,373	116,332	211,847	1,026,754
October	358	55,576	34,635	1,854	127,261	219,684	1,039,483
November	652	52,405	36,623	3,041	104,839	197,560	477,668
December	358	49,186	36,448	2,462	105,108	193,562	685,979
	4,900	805,609	399,469	24,894	1,595,366	2,830,238	11,392,201

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Petroleum produced in Louisiana in 1917 and 1918, in barrels—Continued.

1918.

Month.	Northern Louisiana.					
	Bossier.	Caddo.	De Soto.	Red River.	Sabine.	Total.
January	3,499	414,565	70,157	81,387	448	570,056
February	4,473	455,706	75,657	91,616	231	627,683
March	4,097	615,707	90,453	97,109	352	807,748
April	3,352	809,918	91,428	91,774	412	996,884
May	3,407	955,967	98,169	96,104	410	1,154,057
June	4,538	871,094	91,248	84,724	342	1,051,946
July	3,776	1,137,397	88,147	79,151	380	1,308,851
August	2,811	1,079,359	98,896	89,666	416	1,271,148
September	3,960	1,191,625	93,728	83,903	241	1,373,457
October	3,917	1,284,597	98,755	83,712	403	1,471,384
November	2,761	1,201,350	82,827	81,918	358	1,369,214
December	4,547	1,126,605	86,382	84,199	238	1,304,971
	45,138	11,143,890	1,065,847	1,045,263	4,261	13,304,399

Month.	Coastal Louisiana.							State total.
	Anse la Butte.[a]	Edgerly.	Jennings.	New Iberia.	Vinton.	Welsh.	Total.	
January	250	45,253	36,575	760	128,297	.....	211,135	781,191
February	250	45,066	30,284	760	118,802	.....	195,162	822,845
March	250	44,040	33,980	760	144,953	.....	223,983	1,031,731
April	250	50,800	25,876	1,229	134,913	.....	213,068	1,209,952
May	250	47,245	29,290	760	165,119	.....	242,664	1,396,721
June	250	84,013	27,433	760	172,349	.....	284,805	1,336,751
July	250	40,326	28,822	794	169,006	.....	239,198	1,548,049
August	250	34,784	30,775	760	148,388	.....	214,957	1,486,105
September	250	30,385	31,014	760	152,522	.....	214,931	1,588,388
October	250	31,825	27,742	760	174,698	.....	235,275	1,706,659
November	250	26,923	35,373	760	161,912	2,633	227,851	1,597,065
December	250	31,798	32,335	758	168,124	1,907	235,172	1,537,143
	3,000	512,458	369,499	9,621	1,839,083	4,540	2,738,201	16,042,600

Petroleum produced in Louisiana in 1917 and 1918, with increase or decrease.

District.	1917			1918			Increase or decrease.	
	Quantity (barrels).	Value.	Average price per barrel.	Quantity (barrels).	Value.	Average price per barrel.	Barrels.	Per cent.
Northern Louisiana:								
Bossier	26,188	$53,375	$1.474	45,138	$76,508	$1.695	+ 8,950	+ 24.73
Caddo	5,483,638	9,220,234	1.681	11,143,890	18,938,796	1.699	+5,660,252	+103.22
De Soto	1,370,389	2,450,513	1.798	1,065,847	2,240,214	2.102	— 305,042	— 22.25
Red River	1,664,955	2,340,616	1.406	1,045,263	1,771,280	1.695	— 619,692	— 37.22
Sabine	6,293	11,137	1.770	4,261	8,934	2.097	— 2,032	— 32.29
	8,561,963	14,075,905	1.644	13,304,399	23,035,732	1.731	+4,742,436	+ 55.39
Coastal Louisiana:								
Anse la Butte	4,900	8,575	1.750	[a] 3,000	[a] 5,700	1.900	— 1,900	— 38.78
Edgerly	805,609	916,005	1.137	512,458	791,528	1.545	— 293,151	— 36.39
Jennings	399,469	460,402	1.153	369,499	603,144	1.632	— 29,970	— 7.50
New Iberia	24,894	24,894	1.000	9,621	13,379	1.391	— 15,273	— 61.35
Vinton	1,595,366	1,738,821	1.090	1,839,083	3,076,952	1.673	+ 243,717	+ 15.28
Welsh	.....	.....	.....	4,540	8,625	1.900	+ 4,540	.....
	2,830,238	3,148,697	1.113	2,738,201	4,499,328	1.643	— 92,037	— 3.25
Total Louisiana	11,392,201	17,224,602	1.600	16,042,600	27,535,060	1.716	+4,650,399	+ 40.82

[a] Estimated.

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Petroleum produced, value, and average price per barrel in the Caddo field, 1906–1918.

Year.	Caddo, La.			Marion County, Tex.			Total.		
	Quantity (barrels).	Value.	Average price per barrel.	Quantity (barrels).	Value.	Average price per barrel.	Quantity (barrels).	Value.	Average price per barrel.
1906	3,358	$2,183	$0.650	.....	.....	.....	3,358	$2,183	$0.650
1907	50,000	38,863	.777	.....	.....	.....	50,000	38,863	.777
1908	499,937	214,048	.428	.....	.....	.....	499,937	214,048	.428
1909	1,028,818	549,081	.533	.....	.....	.....	1,028,818	549,081	.533
1910	5,000,793	2,292,349	.451	251,717	$102,842	$0.409	5,342,510	2,395,191	.448
1911	6,995,828	3,653,725	.522	677,689	365,067	.539	7,673,517	4,018,792	.524
1912	7,177,949	5,419,541	.755	362,870	290,974	.802	7,540,819	5,710,515	.757
1913	9,781,560	9,812,342	1.003	262,392	261,965	.998	10,043,952	10,074,307	1.003
1914	7,572,254	7,177,535	.948	180,584	175,922	.974	7,752,838	7,353,457	.948
1915	6,471,879	4,597,558	.710	123,464	88,079	.713	6,595,343	4,685,637	.710
1916	5,463,682	6,123,053	1.121	64,971	80,305	1.236	5,528,653	6,203,358	1.122
1917	5,483,638	9,220,234	1.681	57,952	108,284	1.869	5,541,590	9,328,518	1.683
1918	11,143,890	18,938,796	1.699	48,041	105,613	2.198	11,191,931	19,044,409	1.702
	66,763,586	68,039,308	1.019	2,029,680	1,579,051	.778	68,793,266	69,618,359	1.012

SUMMARY OF WELLS DRILLED.

The statistics of field operations presented in the following tables are compiled from trade-journal sources and differ somewhat from those on page 990, obtained from reports received directly from the oil producers.

Wells completed in Louisiana, 1914–1918.

District.	Oil.					Dry.					Total completed.[a]				
	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918
Northern Louisiana:															
Avoyelles	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	1	.....	.....
Bienville	.....	.....	.....	.....	.....	.....	.....	.....	3	.....	.....	.....	.....	3	.....
Bossier	.....	.....	2	5	5	3	5	22	8	7	3	5	39	32	25
Caddo	208	67	194	241	363	54	32	54	37	41	291	107	269	298	428
Claiborne	.....	.....	.....	.....	.....	.....	.....	.....	2	1	.....	.....	2	6	1
De Soto	77	23	29	28	14	24	17	25	21	8	123	49	64	54	22
La Salle	.....	.....	.....	.....	.....	.....	.....	.....	1	1	.....	.....	.....	1	1
Morehouse	.....	.....	.....	.....	.....	.....	.....	.....	.....	2	.....	.....	.....	1	7
Natchitoches	.....	.....	.....	1	.....	.....	.....	4	3	2	.....	.....	4	4	2
Ouachita	.....	.....	.....	.....	.....	.....	.....	.....	1	2	.....	.....	.....	5	13
Rapides	.....	.....	.....	.....	.....	3	.....	1	.....	.....	3	.....	1	.....	.....
Red River	14	257	99	27	6	7	30	33	17	4	21	296	139	47	11
Sabine	3	2	.....	.....	1	3	5	.....	.....	2	7	7	.....	.....	3
Tensas	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	1	.....	.....
Union	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	3
Webster	.....	.....	.....	.....	.....	.....	.....	.....	3	2	.....	.....	.....	3	2
Winn	.....	.....	.....	.....	.....	.....	.....	.....	2	.....	.....	.....	.....	2	.....
	302	349	324	302	389	94	89	141	98	73	448	464	520	456	518
Coastal Louisiana:															
Allen	.....	.....	.....	.....	.....	.....	.....	.....	2	1	.....	.....	.....	2	1
Arse la Butte	3	1	1	.....	3	.....	3	3	3	5	3	4	4	3	8
Calcasieu	.....	.....	.....	.....	.....	2	2	.....	11	11	2	2	.....	11	11
Cameron	.....	.....	.....	.....	.....	1	.....	3	4	1	1	.....	3	4	1
Edgerly	30	35	44	32	34	16	2	7	10	3	46	38	51	42	37
Evangeline	.....	.....	.....	.....	.....	.....	.....	.....	.....	2	.....	.....	.....	.....	2
Iberia	.....	.....	.....	2	2	.....	.....	.....	13	8	.....	.....	.....	15	10
Jefferson Davis	.....	.....	.....	.....	.....	.....	.....	1	1	4	.....	.....	1	1	4
Jennings	12	16	28	25	29	9	6	14	13	13	21	22	42	38	43
Orleans	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	1
Plaquemines	.....	.....	.....	.....	.....	.....	.....	.....	1	1	.....	.....	.....	1	1
St. Landry	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	1	.....
St. Martin	.....	.....	.....	.....	.....	.....	.....	.....	2	4	.....	.....	.....	2	4
Terrebonne	.....	.....	.....	.....	.....	.....	.....	.....	2	4	.....	.....	.....	4	5
Vermilion	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	1
Vinton	22	19	31	33	45	12	11	12	16	16	35	31	44	51	61
Welsh	5	2	.....	1	4	5	2	1	2	.....	10	4	1	3	4
	72	73	104	93	117	45	26	41	81	75	118	101	146	178	194
Total Louisiana	374	422	428	395	506	139	115	182	179	148	566	565	666	634	712

[a] Including gas well.

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Oil wells and dry holes drilled in Louisiana in 1918.

District.	Jan.		Feb.		Mar.		Apr.		May.		June.		July.		Aug.		Sept.		Oct.		Nov.		Dec.		Total.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Northern Louisiana:																										
Bossier	....	3	1	1	....	....	1	....	1	2	1	....	....	....	1	....	....	....	....	....	....	1	....	....	5	7
Caddo	3	2	24	2	21	2	29	3	31	3	29	4	40	2	33	3	49	4	43	10	27	1	34	5	363	41
Claiborne	....	....	....	....	....	1	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1
De Soto	....	1	1	1	4	2	....	1	2	....	1	2	....	....	2	....	1	....	1	....	....	1	2	....	14	8
La Salle	....	1	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1
Morehouse	....	....	....	....	....	....	....	....	....	....	....	1	....	....	....	....	....	1	....	....	....	....	....	....	....	2
Natchitoches	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1	....	1	....	....	....	....	....	2
Ouachita	....	1	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1	....	2
Red River	....	....	....	....	2	1	1	....	....	1	1	....	....	....	....	....	1	....	1	2	....	....	....	....	6	4
Sabine	....	1	....	....	....	1	1	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1	2
Union	....	....	....	....	....	1	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1
Webster	....	....	....	1	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1	....	....	....	2
	3	9	26	5	27	8	32	4	34	6	32	7	40	2	36	3	51	6	45	13	27	4	36	6	389	73
Coastal Louisiana:																										
Allen	....	....	....	....	....	....	....	....	....	1	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1
Anse la Butte	....	....	....	....	....	....	....	1	....	....	....	2	1	....	....	....	....	....	1	1	1	1	....	....	3	5
Calcasieu	....	1	....	....	....	....	....	1	....	1	....	2	....	2	....	....	....	1	....	2	....	....	....	1	....	11
Cameron	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1	....	....	....	....	....	....	....	1
Edgerly	3	1	3	....	1	....	4	....	7	....	3	....	2	1	2	....	2	....	2	....	2	....	3	1	34	3
Evangeline	....	....	....	....	....	....	....	....	....	1	....	....	....	1	....	....	....	....	....	....	....	....	....	....	....	2
Iberia	....	1	....	1	1	....	1	2	....	2	....	....	....	1	....	....	....	1	....	....	....	....	....	....	2	8
Jefferson Davis	....	1	....	1	....	....	....	....	....	....	....	....	....	1	....	....	....	....	....	1	....	....	....	....	....	4
Jennings	2	2	3	....	1	1	....	3	....	....	3	....	3	1	5	....	3	2	3	2	4	....	2	2	29	13
Orleans	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1	....	....	....	....	....	1
Plaquemines	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1	....	....	....	....	....	....	....	1
St. Martin	....	....	....	....	....	....	....	1	....	1	....	1	....	....	....	....	....	1	....	....	....	....	....	....	....	4
Terrebonne	....	....	....	....	....	....	....	....	....	....	....	2	....	1	....	....	....	1	....	....	....	....	....	....	....	4
Vermilion	....	....	....	....	....	....	....	....	....	....	....	1	....	....	....	....	....	....	....	....	....	....	....	....	....	1
Vinton	2	1	2	....	5	1	3	2	5	2	7	1	3	2	3	....	2	2	5	4	4	....	4	1	45	16
Welsh	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	2	....	2	....	....	....	4	....
	7	7	8	2	8	2	8	10	12	8	13	9	9	10	10	.....	7	10	13	11	13	1	9	5	117	75
Total Louisiana	10	16	34	7	35	10	40	14	46	14	45	16	49	12	46	3	58	16	58	24	40	5	45	11	506	148

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Wells completed in Louisiana, 1914–1918.

Month.	Oil.					Dry.					Total completed.[a]				
	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918
January	28	18	30	28	10	5	5	16	17	16	38	24	53	51	28
February	33	25	42	28	34	10	12	13	14	7	48	41	65	54	44
March	44	23	48	27	35	12	6	14	16	10	60	30	66	50	49
April	35	39	35	32	40	12	12	10	13	14	58	54	47	53	61
May	49	42	44	56	46	18	2	9	21	14	74	45	63	83	64
June	50	49	42	34	45	17	16	12	13	16	69	67	59	51	68
July	33	48	39	42	49	10	8	14	25	12	46	57	55	69	66
August	29	43	38	43	46	12	13	24	16	3	47	59	65	62	56
September	20	40	40	38	58	8	8	21	15	16	36	48	67	56	76
October	12	32	25	36	58	12	10	26	7	24	29	42	53	50	90
November	19	30	24	14	40	11	13	7	13	5	33	46	34	28	50
December	22	33	21	17	45	12	10	16	9	11	36	52	39	27	60
	374	422	428	395	506	139	115	182	179	148	566	565	666	634	712

[a] Including gas wells.

Initial daily production of new wells completed in Louisiana in 1918, in barrels.

District.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Northern Louisiana:													
Bossier	.....	10	.....	75	75	100	.....	75	.....	.....	.....	.....	335
Caddo	60	1,420	14,500	22,380	25,055	10,075	16,265	15,570	23,895	22,830	10,755	5,125	167,930
De Soto	.....	75	250	.....	505	25	.....	625	800	15	.....	300	2,595
Red River	.....	.....	65	25	.....	75	.....	.....	25	40	.....	.....	230
Sabine	.....	.....	.....	15	.....	.....	.....	.....	.....	.....	.....	.....	15
	60	1,505	14,815	22,495	25,635	10,275	16,265	16,270	24,720	22,885	10,755	5,425	171,105
Coastal Louisiana:													
Anse la Butte	.....	.....	.....	.....	.....	.....	25	.....	.....	70	60	.....	155
Edgerly	265	225	125	3,020	740	6,340	530	225	150	2,000	420	60	14,100
Iberia	.....	.....	75	10	.....	.....	.....	.....	.....	.....	.....	.....	85
Jennings	90	250	150	.....	.....	160	205	275	90	110	180	25	1,535
Vinton	260	125	2,100	680	3,920	2,075	375	330	125	7,335	380	2,735	20,440
Welsh	.....	.....	.....	.....	.....	.....	.....	.....	.....	275	100	.....	375
	615	600	2,450	3,710	4,660	8,575	1,135	830	365	9,790	1,140	2,820	36,690
Total Louisiana	675	2,105	17,265	26,205	30,295	18,850	17,400	17,100	25,085	32,675	11,895	8,245	207,795

Total and average initial daily production of new wells in Louisiana, 1914–1918, by districts, in barrels.

District.	Total initial production.					Average per well.				
	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918
Northern Louisiana:										
Bossier	.....	.....	175	240	335	.....	.....	87.5	48.0	67.0
Caddo	19,241	14,320	16,221	49,453	167,930	92.5	213.7	83.6	205.2	462.6
De Soto	70,612	8,190	13,425	6,876	2,595	917.0	356.1	462.9	281.3	185.4
Natchitoches	.....	.....	.....	2	.....	.....	.....	.....	2.0	.....
Red River	12,185	175,551	25,050	2,701	230	870.4	683.1	253.0	100.0	38.3
Sabine	155	55	.....	.....	15	51.7	27.5	.....	.....	15.0
	102,193	198,116	54,871	59,272	171,105	338.4	567.7	169.4	196.3	439.9
Coastal Louisiana:										
Anse la Butte	340	50	300	.....	155	113.3	50.0	300.0	.....	51.7
Edgerly	38,785	32,960	42,725	21,215	14,100	1,292.8	941.7	971.0	663.0	414.7
Iberia	.....	.....	.....	1,650	85	.....	.....	.....	825.0	42.5
Jennings	592	3,390	5,195	1,800	1,535	49.3	211.9	185.5	72.0	52.9
Vinton	43,070	8,715	63,090	21,535	20,440	1,957.7	458.7	2,035.2	652.6	454.2
Welsh	127	70	.....	10	375	25.4	35.0	.....	10.0	93.7
	82,914	45,185	111,310	46,210	36,690	1,151.6	619.0	1,070.3	496.9	273.6
Total Louisiana	185,107	243,301	166,181	105,482	207,795	494.9	576.5	388.3	267.0	410.7

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Total initial daily production of new wells in Louisiana, 1914–1918, by months, in barrels.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.	Monthly average.
1914.....	8,570	10,155	36,805	22,493	17,057	26,212	17,742	10,785	17,367	4,805	6,390	7,226	185,107	15,426
1915.....	4,890	11,985	23,536	23,365	21,356	20,975	29,341	26,230	34,270	17,705	14,400	15,250	243,301	20,275
1916.....	35,580	20,010	21,965	9,040	8,711	10,695	9,905	7,145	11,245	3,010	7,325	11,550	166,181	13,848
1917.....	9,425	5,410	4,365	8,730	18,541	6,615	8,979	6,237	12,045	5,330	3,175	16,530	105,482	8,790
1918.....	675	2,105	17,265	26,205	30,295	18,850	17,400	17,100	25,085	32,675	11,895	8,245	207,795	17,316

ROCKY MOUNTAIN OIL FIELD.

GENERAL STATEMENT.

The Rocky Mountain field embraces all areas of production of petroleum in Colorado, Wyoming, and Montana, as well as a number of areas of prospective production in Utah and New Mexico. Petroleum in this field is obtained from strata of Carboniferous and Cretaceous age, the oil occurring generally in sandstone layers, though found occasionally in limestone and rarely in fracture zones in shale. Anticlinal and dome structures are the most favored places of accumulation of oil, though areas of commercial production have been found in this field on monoclinal and terrace structures. The oils from older strata range in gravity from 18° to 24° Baumé, are of asphalt base, and are utilized chiefly for fuel; those from the Cretaceous rocks range between 32° and 48° Baumé, are of paraffin base, and are in wide demand for refining.

Statistics of production in the oil districts of Wyoming, Colorado, and Montana indicate an output in 1918 of 12,808,896 barrels, an increase of 3,609,586 barrels, or 39.24 per cent, as compared with the output in 1917. The value of the output in 1918 was $18,474,078, as compared with $11,322,248 in 1917. The average price received at the wells for all grades of Rocky Mountain oil in 1918 was $1.44 per barrel, a gain of 21 cents, or 17 per cent, over the average in 1917. The posted market price of Grass Creek-Elk Basin grade, the class which includes the greater part of the oil sold in the open market in this field, opened the market at $1.70 a barrel and advanced on March 21 to $1.85, remaining stationary at this price to the end of the year.

PETROLEUM PRODUCED.

Petroleum produced in the Rocky Mountain field in 1917 and 1918, in barrels.

Month.	1917				1918			
	Colorado.	Wyoming.	Montana.	Total.	Colorado.	Wyoming	Montana.	Total.
January.....	11,869	589,075	10,954	611,898	10,177	839,972	6,334	856,483
February.....	10,324	643,504	10,504	664,332	10,300	765,886	5,731	781,917
March.....	9,541	740,304	11,040	760,885	12,110	1,043,617	6,611	1,062,338
April.....	10,184	779,486	9,676	799,346	11,627	954,977	5,985	972,589
May.....	10,396	740,778	9,186	760,360	12,563	1,074,774	6,369	1,093,706
June.....	10,179	735,077	8,076	753,332	11,696	1,072,806	5,654	1,090,156
July.....	10,655	726,936	7,224	744,815	12,084	1,120,612	6,307	1,138,953
August.....	11,122	751,932	7,157	770,211	12,429	1,171,369	5,732	1,189,830
September....	9,352	809,690	6,671	825,713	13,327	1,092,311	5,351	1,110,989
October.....	8,843	840,561	6,632	856,036	12,433	1,170,191	5,438	1,188,062
November....	8,715	775,011	6,297	790,023	12,217	1,169,366	4,549	1,186,133
December.....	10,051	846,326	5,982	862,359	12,373	1,120,106	5,262	1,137,741
	121,231	8,978,680	99,399	9,199,310	143,286	12,596,287	69,323	12,808,896

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Petroleum produced in the Rocky Mountain field, 1887–1918.

Year.	Quantity (barrels).	Percentage of total production of United States.	Increase or decrease.		Value.	Yearly average price per barrel.
			Barrels.	Per cent.		
1887	76,295	0.27	.....	.....	$76,295	$1.000
1888	297,612	1.07	+ 221,317	+ 29.01	267,851	.900
1889	316,476	.90	+ 18,864	+ 6.34	280,240	.885
1890	368,842	.80	+ 52,366	+ 16.54	309,827	.840
1891	665,482	1.22	+ 296,640	+ 80.42	559,005	.840
1892	824,000	1.63	+ 158,518	+ 23.82	692,160	.840
1893	594,390	1.22	− 229,610	− 27.86	497,581	.838
1894	518,115	1.05	− 76,275	− 12.83	319,572	.617
1895	441,687	.83	− 76,428	− 14.75	363,650	.823
1896	364,328	.59	− 77,359	− 17.51	342,001	.939
1897	388,584	.64	+ 24,256	+ 6.66	361,322	.930
1898	449,858	.80	+ 61,274	+ 15.77	405,772	.902
1899	395,838	.69	− 54,020	− 12.01	443,030	1.119
1900	322,835	.50	− 73,003	− 18.44	361,584	1.120
1901	465,920	.66	+ 143,085	+ 44.32	498,831	1.071
1902	403,154	.45	− 62,766	− 13.47	528,454	1.311
1903	492,885	.48	+ 89,731	+ 22.26	494,443	1.003
1904	513,305	.43	+ 20,420	+ 4.14	658,829	1.284
1905	384,692	.28	− 128,613	− 25.06	389,151	1.012
1906	334,582	.26	− 50,110	− 13.03	311,675	.932
1907	341,190	.205	+ 6,608	+ 1.98	294,696	.863
1908	397,428	.22	+ 56,238	+ 16.48	374,323	.942
1909	330,917	.18	− 66,511	− 16.74	352,618	1.066
1910	355,224	.17	+ 24,307	+ 7.35	336,938	.949
1911	413,621	.185	+ 58,397	+ 16.44	352,141	.851
1912	1,778,358	.80	+1,364,737	+329.95	998,131	.561
1913	2,595,321	1.04	+ 816,963	+ 45.94	1,362,011	.525
1914	3,783,148	1.43	+1,187,827	+ 45.77	1,880,086	.497
1915	4,454,000	1.585	+ 670,852	+ 17.73	2,400,503	.539
1916	6,476,289	2.153	+2,022,289	+ 45.40	5,905,238	912
1917	9,199,310	2.74	+2,723,021	+ 42.05	11,322,248	1.231
1918	12,806,896	3.60	+3,609,586	+ 39.24	18,474,078	1.442
	51,552,582	1.12	.....	.....	52,214,284	1.013

Petroleum produced, value, and average price per barrel in the Rocky Mountain field, 1909–1918, by States.

Year.	Colorado.			Wyoming.			Montana.			Total.		
	Quantity (barrels).	Value.	Average price per barrel.	Quantity (barrels).	Value.	Average price per barrel	Quantity (barrels).	Value.	Average price per barrel.	Quantity (barrels).	Value.	Average price per barrel.
1909	310,861	$318,162	$1.023	a20,056	$34,456	$1.718	.....	.....	.....	330,917	$352,618	$1.066
1910	239,794	243,402	1.015	a115,430	93,536	.810	.....	.....	.....	355,224	336,938	.949
1911	226,926	228,104	1.005	a186,695	124,037	.664	.....	.....	.....	413,621	352,141	.851
1912	206,052	199,661	.969	1,572,306	798,470	.507	.....	.....	.....	1,778,358	998,131	.561
1913	188,799	174,779	.926	2,406,522	1,187,232	.493	.....	.....	.....	2,595,321	1,362,011	.525
1914	222,773	200,894	.902	3,560,375	1,679,192	.472	.....	.....	.....	3,783,148	1,880,086	.497
1915	208,475	183,485	.880	4,245,525	2,217,018	.522	.....	.....	.....	4,454,000	2,400,503	.539
1916	197,235	217,139	1.101	6,234,137	5,644,080	.905	44,917	$44,019	$0.980	6,476,289	5,905,238	.912
1917	121,231	128,100	1.057	8,978,680	11,047,876	1.230	99,399	146,272	1.472	9,199,310	11,322,248	1.231
1918	143,286	188,472	1.315	12,596,287	18,159,778	1.442	69,323	125,828	1.815	12,806,896	18,474,078	1.442

a Includes Utah.

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Petroleum produced in the Rocky Mountain field, 1914–1918, in barrels.

Month.	1914	1915	1916	1917	1918
January	216,558	356,351	366,551	611,898	856,483
February	179,011	270,688	248,896	664,332	781,917
March	246,825	370,698	506,230	760,885	1,062,338
April	318,235	214,858	491,451	799,346	972,589
May	394,112	263,115	526,982	760,360	1,093,706
June	239,295	409,386	547,773	753,332	1,090,156
July	307,244	411,504	550,792	744,815	1,138,953
August	398,804	451,764	657,303	770,211	1,189,830
September	406,472	388,863	652,003	825,713	1,110,989
October	394,274	469,690	639,152	856,036	1,188,062
November	362,773	409,598	617,535	790,023	1,186,132
December	319,545	437,487	671,621	862,359	1,137,741
	3,783,148	4,454,000	6,476,289	9,199,310	12,808,896

Average daily production of petroleum in the Rocky Mountain field, 1914–1918, in barrels.

Month.	1914	1915	1916	1917	1918
January	6,986	11,495	11,824	19,713	27,629
February	6,393	9,664	8,889	23,726	27,926
March	7,962	11,958	16,330	24,545	34,269
April	10,608	7,162	16,382	26,645	32,420
May	12,713	8,487	16,999	24,528	35,281
June	7,980	13,646	18,259	25,111	36,339
July	9,911	13,274	17,767	24,026	36,740
August	12,864	14,573	21,203	24,846	38,382
September	13,549	12,962	21,733	27,524	37,033
October	12,719	15,151	20,618	27,614	38,325
November	12,092	13,653	20,585	26,334	39,538
December	10,308	14,112	21,665	27,818	36,701
Average	10,365	12,203	17,743	25,203	35,093

PIPE-LINE RUNS, DELIVERIES, AND STOCKS.

Pipe-line runs and deliveries to trade of petroleum from the Rocky Mountain field and stocks at end of each month in 1917 and 1918, in barrels.

Month.	1917			1918		
	Runs.	Deliveries.	Stocks.	Runs.	Deliveries.	Stocks.
Dec. 31, 1916			745,181			
January	611,898	453,756	903,323	856,483	855,698	516,126
February	664,332	689,243	878,412	781,917	784,082	513,961
March	760,885	871,004	768,293	1,062,338	934,063	642,236
April	799,346	700,342	867,297	972,589	858,514	756,311
May	760,360	782,444	845,213	1,093,706	968,967	881,050
June	753,332	767,820	830,725	1,090,156	1,061,162	910,044
July	744,815	874,464	701,076	1,138,953	1,062,116	986,881
August	770,211	854,968	616,309	1,189,830	1,050,758	1,125,953
September	825,713	865,273	576,749	1,110,989	1,189,061	1,047,881
October	856,036	851,787	581,008	1,188,062	1,249,884	986,059
November	790,023	876,153	494,878	1,186,132	1,205,367	966,824
December	862,359	841,896	515,341	1,137,741	1,189,831	914,734
	9,190,310	9,429,150		12,808,896	12,409,503	

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PRICES.

Prices of Wyoming petroleum in 1917 and 1918, per barrel.

1917			1918		
Date.	Grass Creek and Elk Basin.	Big Muddy.	Date.	Grass Creek and Elk Basin.	Big Muddy.
Jan. 1	$1.10	.....	Jan. 1	$1.70	$1.15
Jan. 2	1.20	$0.85	Feb. 9	.....	1.30
Jan. 8	1.30	.95	Mar. 21	1.85	1.50
Jan. 30	1.35	.....			
Mar. 23	1.40	.....			
July 6	1.45	1.00			
July 12	1.50	1.05			
Aug. 21	1.70	1.15			

COLORADO.

GENERAL STATEMENT.

The total production of oil in Colorado in 1918 was 143,286 barrels, an increase of 22,055 barrels, or 18 per cent, as compared with the output in 1917. Increase in production came from the Florence district in Fremont County, which produced in 1918 a total of 134,895 barrels, as compared with 114,664 barrels in 1917. Decrease in production is reported from the Boulder district in Boulder County. A small production is also reported from Mesa and Rio Blanco counties. The average price received for Colorado oil at the wells in 1918 was $1.315 a barrel, an average increase of 26 cents, as compared with 1917. The total value of the output in 1918 was $188,472, as compared with $128,100 in 1917.

DEVELOPMENT.

The following wildcat tests were completed in Colorado in 1918: In Adams County, the Mid-Colorado Oil & Gas Co. is reported to have abandoned its test at Aurora, 9 miles east of Denver, at 3,740 feet, after three years' work. In Washington County, in sec. 2, T. 2 N., R. 53 W., a test well was drilled by the Akron Oil & Gas Co. to a total depth of 4,200 feet; it obtained a trace of oil at 2,000 feet and a little gas at 3,800 feet. In Pueblo County, in sec. 14, T. 20 S., R. 66 W., a well, drilled by the Eureka Oil Co., was reported in September as abandoned at 1,800 feet. In Kiowa County, in sec. 36, T. 17 S., R. 49 W., a showing of oil was reported in a well drilled by the Rush Creek Oil Co.

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PETROLEUM PRODUCED.

Petroleum produced in Colorado in 1917 and 1918, by districts, in barrels.

Month	1917			1918		
	Boulder.	Florence.	Total.[a]	Boulder.	Florence.	Total.[b]
January	868	10,941	11,809	274	9,599	10,177
February	461	9,803	10,324	307	9,689	10,300
March	423	9,058	9,541	308	11,498	12,110
April	621	9,503	10,184	274	11,039	11,627
May	423	9,913	10,396	274	11,975	12,563
June	423	9,696	10,179	357	11,024	11,686
July	423	10,172	10,655	315	11,404	12,084
August	423	10,639	11,122	291	11,823	12,429
September	423	8,869	9,352	326	12,686	13,227
October	423	8,360	8,843	285	11,833	12,433
November	482	8,173	8,715	339	11,563	12,267
December	454	9,537	10,051	1,296	10,762	12,373
	5,847	114,664	121,231	4,646	134,895	143,286

[a] Includes production in Garfield County.
[b] Includes production in Garfield and Rio Blanco counties.

Petroleum produced, value, and average price per barrel in Colorado, 1909–1918, by districts.

Year.	Boulder.			Florence.			Total.		
	Quantity (barrels).	Value.	Average price per barrel.	Quantity (barrels).	Value.	Average price per barrel.	Quantity (barrels).	Value.	Average price per barrel.
1909	85,709	$120,812	$1.514	225,052	$187,902	$0.834	[a] 310,861	$318,162	$1.023
1910	42,186	63,420	1.503	193,482	174,332	.901	[b] 239,794	243,402	1.015
1911	37,973	50,393	1.327	187,341	175,763	.938	[b] 228,926	228,184	1.085
1912	15,304	19,130	1.250	190,498	180,281	.946	[c] 206,052	199,661	.969
1913	11,796	15,366	1.303	176,693	159,103	.900	[c] 188,799	174,779	.926
1914	6,515	9,117	1.399	215,548	191,067	.886	[d] 222,773	200,894	.902
1915	6,376	9,679	1.518	202,069	173,506	.859	[a] 208,475	183,485	.880
1916	5,749	9,902	1.722	191,496	207,237	1.082	197,235	217,139	1.101
1917	5,847	11,510	1.969	114,664	115,150	1.004	[a] 121,231	128,100	1.057
1918	4,646	10,654	2.293	134,895	172,666	1.280	[b] 143,286	188,472	1.315

[a] Includes a small production in Garfield County.
[b] Includes production in Garfield and Rio Blanco counties.
[c] Includes production in Rio Blanco County.
[d] Includes production in Mesa and Rio Blanco counties.

FIELD REPORT.

Field report for oil industry in Colorado in 1917 and 1918.

County.	Wells.									Acreage.					
	1917					1918				1917			1918		
	Productive Jan. 1.	Completed. Oil.	Completed. Dry.	Abandoned.	Productive Dec. 31.	Completed. Oil.	Completed. Dry.	Abandoned	Productive Dec. 31.	Fee.	Lease.	Total.	Fee.	Lease.	Total
Adams			1												
Boulder	14			2	12			2	10	2,629	93	2,722	856	53	909
Delta			1												
Fremont	56	5	10	3	58	4	5	1	61	5,425	20,420	25,845	7,523	46,243	53,766
Garfield	1		2		1				1	1,440		1,440	1,440		1,440
Moffat							1							10,000	10,000
Pueblo							1							2,880	2,880
Rio Blanco	14	6	2		20	8	3		28	2,320		2,320	1,600	5,640	7,240
Routt			1												
San Miguel			1												
Washington			1				1			3,440		3,440			
	85	11	19	5	91	12	11	3	100	15,254	20,513	35,767	11,419	64,816	76,235

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WYOMING.

GENERAL STATEMENT.

Wyoming showed a steady increase in production of crude oil in 1918, furnishing a total output of 12,596,287 barrels, an increase of 3,617,607 barrels, or 40 per cent, as compared with the output in 1917.

Converse County had the largest increase in production, 3,082,026 barrels in 1918, as compared with 665,432 barrels in 1917. Hot Springs, Natrona, and Fremont counties also showed a marked increase in production. A decrease was reported from Big Horn, Park, and Uinta counties. The average price received at the wells for Wyoming oil was $1.44 per barrel, an increase of 21 cents, or 17 per cent, as compared with the average price in 1917. The value of the total output in 1918 was $18,159,778, as compared with $11,047,876 in 1917.

DEVELOPMENT.

Records of field operations compiled from trade-journal sources and comparable to the records used in discussing field operations in other States have not been compiled by the Survey prior to 1918. These records for 1918 show total completions for the year of 250 wells, of which 158 were oil wells credited with an average initial yield of 106.45 barrels per day, 29 produced gas only, and 63, or 25 per cent, were dry holes.

Natrona County continued as the leading producer of oil in Wyoming in 1918 and furnished 42 per cent of the total output of the State for the year. The Salt Creek field continued to furnish new wells of large capacity, the best of which was the well of the Mid West Refining Co., in sec. 25, T. 40 N., R. 79 W., which was brought in late in September and is reported to have started flowing 8,000 to 10,000 barrels a day. Production was reported from the so-called "Lower Wall Creek sand." A total of 63 wells were reported drilled in Natrona County during the year, of which 28 were oil wells, credited with an average initial yield of 312.5 barrels a day.

The marked increase in production in Converse County was due to the rapid development during the year of the Big Muddy district. A total of 55 wells were drilled in this county during the year, of which 47 started producing at the rate of 160.3 barrels a day.

The most important discovery of the year was that of the Lance Creek field in Niobrara County. A discovery well in the Lance Creek field in sec. 36, T. 36 N., R. 65 W., was brought in at a depth of 665 feet by the Ohio Oil Co., on October 6, 1918. At that time the yield of the well was estimated at 1,200 barrels a day. Some small wells had been completed in the same general district at shallower depths earlier in the year, but the discovery of the deep sand marked the opening of an important field.

The oil from the deep sand is low in sulphur and the highest specific gravity contains from 45 to 50 per cent gasoline. Another important discovery was made by the Ohio Oil Co. on the Rock Creek dome in Carbon County in the spring of 1918. The most interesting disappointment during the year in development work in Wyoming was the striking of a large salt-water well on the Tisdale dome to the west of the Salt Creek field. This structure during the past few years has been looked upon as one of the best prospects for oil in Wyoming.

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Near the Lost Soldier field the Producers & Refiners Corp. found a very productive spot on the Ferris dome where a 500-barrel well was obtained at a depth of 1,536 feet. In the Big Horn Basin interest was centered in the early part of the year on the Warm Springs anticline east of Thermopolis, where a number of good wells were reported.

Dry holes were reported on the Duncan dome, 25 miles southwest of Thermopolis, and in the Lucerne dome, 65 miles south of Thermopolis. A large salt-water well was reported from the Murphy dome in Hot Springs County.

PETROLEUM PRODUCED.

Petroleum produced in Wyoming in 1917 and 1918, by counties, in barrels.

Month.	Big Horn.	Fremont.	Natrona.	Hot Springs.	Park.	Converse.	Uinta.	Total.
1917.								
January	2,889	3,809	286,902	160,160	119,647	15,325	343	589,075
February	2,395	3,425	312,588	164,391	141,095	19,425	185	643,504
March	6,230	3,047	351,616	193,053	165,893	20,257	208	740,304
April	4,620	7,847	375,680	206,075	164,867	20,217	180	779,486
May	6,735	5,089	325,096	227,543	147,716	27,854	745	740,778
June	7,432	4,339	307,733	241,595	129,592	44,007	379	735,077
July	7,038	4,836	309,640	255,969	103,001	45,950	502	726,936
August	6,268	4,650	317,045	263,820	117,942	41,914	293	751,932
September	5,609	3,811	338,383	262,053	119,856	79,540	438	809,690
October	4,395	3,453	358,997	251,277	111,379	110,732	328	840,561
November	3,504	4,556	286,884	258,958	108,936	111,901	272	775,011
December	4,925	935	339,947	271,508	100,340	128,310	361	846,326
	62,040	49,797	3,910,511	2,756,402	1,530,264	665,432	4,234	8,978,680
1918.								
January	2,845	734	325,258	273,326	97,304	139,874	631	839,972
February	2,291	734	262,464	251,017	94,854	154,486	40	765,886
March	4,871	734	471,654	281,884	98,064	186,075	335	1,043,617
April	2,613	6,134	379,171	264,340	80,086	222,297	336	954,977
May	4,559	1,168	454,549	267,975	82,441	263,749	333	1,074,774
June	3,632	1,834	471,828	250,775	73,654	270,748	335	1,072,806
July	3,268	734	469,039	265,587	91,290	290,652	42	1,120,612
August	4,427	10,124	490,192	251,032	91,510	323,863	521	1,171,669
September	3,742	24,124	410,958	223,478	110,652	319,126	231	1,092,311
October	4,863	24,502	502,995	226,883	104,072	306,834	42	1,170,191
November	4,132	14,983	593,640	191,838	74,596	289,752	425	1,169,366
December	4,017	24,378	505,179	203,320	68,313	314,570	329	1,120,106
	45,260	110,183	5,336,927	2,951,455	1,066,836	3,082,026	[a] 3,600	12,596,267

[a] Includes small production from Crook County.

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Petroleum produced, value, and average price per barrel in Wyoming, 1914–1918, by districts.

Year.	Big Horn.			Fremont.			Natrona.		
	Quantity (barrels).	Value.	Average price per barrel.	Quantity (barrels).	Value.	Average price per barrel.	Quantity (barrels).	Value.	Average price per barrel.
1914	96,178	$96,178	$1.00	27,395	$21,362	$0.780	3,421,325	$1,541,494	$0.451
1915	140,978	133,457	.946	27,660	15,051	.544	3,971,128	1,985,564	.500
1916	139,854	150,884	1.079	62,564	87,275	1.395	3,933,463	3,363,364	.855
1917	62,040	101,549	1.637	49,797	31,113	.625	3,910,511	3,723,291	.952
1918	45,260	78,156	1.727	110,183	115,089	1.045	5,335,927	6,195,684	1.161

Year.	Hot Springs.			Park.			Converse.		
	Quantity (barrels).	Value.	Average price per barrel.	Quantity (barrels).	Value.	Average price per barrel.	Quantity (barrels).	Value.	Average price per barrel.
1914							(a)	(a)	
1915	98,723	$74,126	$0.751				(a)	(a)	
1916	1,369,807	1,336,840	.976	720,988	$685,571	$0.965	(a)	(a)	
1917	2,756,402	4,190,774	1.523	1,530,264	2,266,794	1.481	665,432	$726,738	$1.092
1918	2,951,455	5,312,714	1.800	1,066,836	1,935,311	1.814	3,062,026	4,515,159	1.465

Year.	Other.			Total.		
	Quantity (barrels).	Value.	Average price per barrel.	Quantity (barrels).	Value.	Average price per barrel.
1914	[b] 15,477	[b] $20,158	$1.302	3,560,375	$1,679,192	$0.472
1915	[c] 7,038	[c] 8,820	1.254	4,245,525	2,217,018	.522
1916	[d] 7,521	[d] 10,146	1.349	6,234,137	5,644,080	.905
1917	[e] 4,234	[e] 7,617	1.780	8,978,680	11,047,876	1.230
1918	[f] 3,600	[f] 7,665	2.129	12,596,287	18,159,778	1.442

[a] Included in Other.
[b] Converse, Crook, and Uinta counties.
[c] Converse, Park, and Uinta counties.
[d] Converse and Uinta counties.
[e] Uinta County.
[f] Uinta and Crook counties.

FIELD REPORT.

Field report for oil industry in Wyoming in 1917 and 1918.

County.	Wells.									Acreage.					
	1917					1918				1917			1918		
	Productive Jan. 1.	Completed.		Abandoned.	Productive Dec. 31.	Completed.		Abandoned.	Productive Dec. 31.	Fee.	Lease.	Total.	Fee.	Lease.	Total.
		Oil.	Dry.			Oil.	Dry.								
Big Horn	110	6	11	33	83	19	11	23	79	219	6,869	7,088	3,741	8,316	12,057
Carbon		8	2		8	10	5	1	17		5,680	5,680	4,600	6,446	11,046
Converse	17	81	19	2	96	73	19	2	167	2,440	7,723	10,163	1,760	18,475	20,235
Crook	12				12	1	2		13	760	800	1,560	1,120	14,800	15,920
Fremont	37	13	3		50	22	13	1	71	183	11,808	11,991	3,769	16,942	20,711
Hot Springs	96	146			242	73	15	3	312		3,532	3,532	1,600	11,557	13,157
Lincoln							4							2,000	2,000
Natrona	125	25	10	13	138	35	38	1	172	6,460	46,765	53,225	1,680	47,906	49,586
Niobrara		19	1		19		2	18	1		5,320	5,320		2,640	2,640
Park	27	10	3		37	43	2		80	320	3,120	3,440	320	7,693	8,013
Platte							1							20,000	20,000
Sweetwater			1			1	3		1		630	630	2,000	630	2,630
Uinta	32			1	31			13	18	7,640	800	8,440	120	3,400	3,520
	457	308	50	49	716	277	115	62	931	18,022	93,047	111,069	20,710	160,805	181,515

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MONTANA.

GENERAL STATEMENT.

The quantity of petroleum marketed from wells in 1918 was 69,323 barrels, a decrease of 30,076 barrels, or 30 per cent, as compared with the output in 1917. The entire production came from wells in Carbon County, in the north end of the Elk Basin district.

DEVELOPMENT.

Prospecting work for petroleum fields in Montana in 1918 was practically at a standstill. A few wells in widely separated localities were completed during the year, but none of these localities showed promise of developing into an oil field. In Cascade County, at Sun River, 60 miles west of Great Falls, a gas well was drilled early in the year with a capacity of 50,000 cubic feet. Some gas wells were also developed in Sweet Grass County, about 70 miles north of Great Falls. A well drilled by the Montana Yellowstone Oil Co. in sec. 4, T. 14 N., R. 55 E., Dawson County, was reported in August to have reached a depth of 4,000 feet.

PETROLEUM PRODUCED.

Petroleum produced in Montana in 1917 and 1918, in barrels.

Month.	1917	1918	Month.	1917	1918
January	10,954	6,334	August	7,157	5,732
February	10,504	5,731	September	6,671	5,251
March	11,040	6,611	October	6,632	5,438
April	9,676	5,965	November	6,297	4,549
May	9,186	6,369	December	5,982	5,262
June	8,076	5,654			
July	7,224	6,307	Total	99,399	69,323

CALIFORNIA.

By Walter A. English.

GENERAL STATEMENT.

The year 1918 saw a substantial increase in California in the production of crude petroleum from 93,000,000 to more than 97,000,000 barrels. Since 1913, when a production of 97,000,000 barrels was reached, the quantity annually produced has varied between 90,000,000 and 100,000,000 barrels, except in 1915, when it fell to 86,000,000 barrels. This rather uniform production has prevailed during a series of years which have seen much greater changes in the production of the principal eastern fields.

The increase in quantity of oil produced in 1918 was accompanied by a slight change to an average of slightly higher gravity, largely because of the increasing importance of the southern California fields. A new grade of oil for this State has also come on the market, the Ventura County paraffin-base oil, from which various paraffin products are now being manufactured in the refinery at Santa Paula.

The average price for the year was $1.21 a barrel, this being the first year since 1894 that crude oil has averaged over $1 a barrel at the well. As production in volume in California did not begin until

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about the year 1900, it may be said that this is the first appearance of "dollar oil" in the history of the State. Price changes during the year were upward, the base price quoted by the Standard Oil Co. being raised on May 1 from $0.98 to $1.23 a barrel. Present conditions in the industry promise an indefinite continuation of this upward tendency of prices unless checked by large imports of foreign fuel oil. The tendency to give a greater differential for high gravity oil was continued in 1918. This is a natural result of the increasing demand of oil for refining as opposed to the demand for fuel oil.

That the stimulation of high prices to greater production was not greater is due chiefly to two factors. The first factor is the increased cost of all labor and of materials used in the oil industry. The 8-hour day and increased wages, together with the unprecedented cost of all steel equipment, have absorbed into the cost of production much of the increased price received for the oil. The other factor is the decrease in extent of territory favorable for wildcatting and the gradual drilling up of the proved territory. California has already maintained her peak production for six years and will probably continue to do so for several years more, a feat not duplicated by any of the older fields of the country. As a field becomes older it naturally becomes less responsive to the stimulation of high prices.

As in 1917 the total consumption outstripped production with a resulting lowering of stocks during 1918 to the extent of about 500,000 barrels.

The year saw general strengthening of larger companies at the expense of small ones. The established companies were able almost to exclude new organizations from drilling the expensive tests in deep wildcat territory in southern California. The larger companies have a large proportion of the good land in the newly developed Montebello field.

Many of the important properties in the Midway district continued to be operated by a receiver as a result of the legal controversy over the withdrawals of land by the United States in 1909 and 1910. A few claims were allowed to go to patent after investigation by the Interior Department, but the majority are still held up pending action by Congress. The most important legal decision of the year was in the Elk Hills land case, which was decided by the United States circuit court of appeals in favor of the Southern Pacific Co. The case was appealed by the Government to the United States Supreme Court. If this decision is not reversed it probably means that the title of the railroads to all oil lands received in grants in the State is valid.

During the year electric motors were tried out at several places for drilling wells. Two wildcat wells of the Shell Co., southwest of Puente were equipped with motors, as was the Buick well near the San Fernando tunnel. Several wells in the Santa Paula field were drilled by motors. From all accounts it appears that this type of power is fairly satisfactory and sufficiently flexible, though requiring slightly different methods of manipulation by the driller. An innovation was the use by the Brea Canyon Oil Co. of oil as a drilling fluid in one of its wells. It was claimed that the use of oil instead of water reduced the tendency of the casing to freeze.

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DEVELOPMENT.

VALLEY FIELDS.

In 1918 only 491 oil wells were completed in the Valley fields, as against 563 in 1917. As a result, the total production for these fields dropped from 69,000,000 to 65,000,000 barrels. The falling off in new wells and in production was particularly marked in the Midway-Sunset field which fell off nearly 10 per cent in monthly production between the first and the last months of the year. Until land now in litigation is open to active development, this, the largest field in the State, seems due for a slow decline from year to year.

Coalinga.—Drilling activity continued in the Coalinga field at about the same rate as in 1917, and was confined almost entirely to proved territory. The Shell Co., operating in the east-side field, was particularly active. This company successfully used the mudding process to shut off water in some of its wells. Water troubles, which at one time seriously threatened the west side, seem to have been successfully averted. The Crescent wildcat well at the south end of the Kettleman Hills was abandoned as dry at 3,500 feet. The Southern Pacific Co. has begun a wildcat test in the Parkfield district, 20 miles southwest of Coalinga.

Lost Hills.—The number of completed oil wells in the Lost Hills dropped from 72 to 23, as compared with the previous years, with a resultant drop in production from 4,000,000 to 3,600,000 barrels. The development in 1917 was exceedingly rapid, the size of the field considered, and it was to be expected that this rate could not be kept up indefinitely. No new territory was proved during 1918 and the development of the half-proved north extension of the field was disappointing.

Belridge.—As in the Lost Hills district, 1918 saw a falling off in development in Belridge. Several wells were drilled to the shallow sand, but these did not offset the natural decline of the older wells. No new territory was proved.

McKittrick.—The combined production of McKittrick and Belridge was 4,815,610 barrels, of which about two-thirds came from the old McKittrick field. The latter is one of the oldest fields in the State, and though almost completely drilled up its wells are holding out very well, even though a decline in production from year to year is now inevitable.

The Standard Oil Co. continued its deep drilling on the "front," and though "shows" and small short flows were obtained, the water conditions have not been mastered thus far. A large gas well was struck by the Doheny-Pacific Petroleum Co. in sec. 2 (31–32) south of McKittrick.

Midway.—The new production of the 153 wells completed during 1918 in this field was insufficient to offset the loss due to decline and abandonment of older wells, the annual marketed production falling from 28,829,674 barrels in 1917 to 26,407,728 barrels in 1918.

The Southern Pacific, Standard, and Santa Fe were the most active developing companies, the latter two, desiring fuel oil, paid particular attention to the low gravity territory. Toward the end of the year a slight slackening in demand for fuel oil caused a decline from the most active development. No big gushers were brought in during

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the year. A thousand-barrel well is now considered a big well, and the field average for all wells has fallen to below 50 barrels per well. Nevertheless the field still retains its place as the largest single field in California, and probably has the largest reserve of oil in any field in the United States.

Sunset.—The year 1918 saw an increase in drilling activity, as compared with 1917, with 82 completions as against 64. This increase in wells was, however, not sufficient to offset the natural decline of wells previously drilled, and a falling off of nearly 10 per cent in production took place. Water conditions in this field have proved among the most difficult to combat, owing to the close association of oil and water sands. Despite this handicap substantial progress has been made in correcting and preventing water trouble. The year failed to see the completion of any of the prolific and spectacular gushers which made the Maricopa Flat famous a few years ago. Wells of over a thousand barrels of initial flow are still obtained occasionally, but the flush gusher production of the big wells is a thing of the past, even though the field is far from completely developed.

Kern River.—The output of Kern River during 1918 of 7,500,237 barrels represents a decline of nearly 8 per cent from the 8,144,348 barrels produced in 1917, and less than half the maximum annual production. The rate of decline for 1918 from 1917 was 7.91 per cent, although the decline in 1916–17 was only 1 per cent. This increased rate of decline represents a resumption of the normal decline which was broken by the active campaign of 1917 to repair old wells and get more oil by better methods of production. As these changes are completed the old rate of decline once again asserts itself. Despite the "old age" status of the proved field, Kern River may one day come to life with another boom because of extensions to the northwest. The Standard Oil Co., of California, has been drilling in this region for several years and has produced oil from several wells, but has thus far failed to complete a steady producer. In September it started well No. 5 on sec. 21 (28, 27), despite the fact that previous wells have not yet become commercial producers, thus indicating the faith of this company in the ultimate success of operations in the Kern River front. The Hale syndicate is also drilling north of Kern River near McFarland, and the Visalia-Midway to the south of Edison.

COASTAL DIVISION.

The number of new wells completed in the coastal division was 79, as compared with 52 in 1917. The greater part of these were drilled in the course of the rapid development of the new Casmalia field, and of the South Mountain field in Ventura County. The increase in annual production from 5,910,238 barrels to 6,848,904 barrels, as compared with 1917, was also largely because of the increase brought about by new wells in the above-mentioned fields.

Santa Clara County.—During the year some of the old wells in Moody's Gulch were cleaned out, and what might be termed a rejuvenated flush production of a few barrels per day of very light oil was obtained. At the Sargent field a deep test failed to disclose anything worth while.

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San Luis Obispo County.—The Tiber Oil Co., in the Edna district, increased its production to some 4,000 barrels a month. This district accounts for most of the combined Santa Clara and San Luis Obispo production.

Santa Barbara County.—The 11.94 per cent increase in marketed oil over the previous year is largely a result of continued active drilling in the Casmalia district. The Associated Co., desiring a large production of this grade of oil, had as many as eight drilling outfits working on their property. The Doheny-Pacific Petroleum Co., in the same field, installed a cracking plant which, unlike most cracking plants, was not designed primarily to produce greater quantities of light distillates but to reduce the viscosity of the heavy oil so that it could be pumped through pipe lines without excessive heating. The old Santa Maria field saw only a small amount of development, and in the Cat Canyon and Lompoc districts there was very little new work.

Tests northwest of Los Alamos have on the whole been disappointing, a number of deep holes yielding only a small output of oil. During the year the Standard Oil Co. of California finished its fifth deep test in the Santa Maria district, all of them dry holes, and it has, for the present at least, given up operations in this region.

Ventura County.—The outstanding feature of the year was the development in the South Mountain field directly south of Santa Paula. It was largely because of this development that the oil marketed increased 37.94 per cent over 1917. Although the productive area in this new field will not likely be very large, the high quality paraffin-base oil obtained makes this field a valuable addition to the California resources.

During the year the various companies continued efforts to shut off water in the light-oil field in Ventura Canyon. An oil of lesser gravity was also struck half a mile to the west of the wells producing the 54° gravity oil.

In the Simi district the Doheny-Pacific Petroleum Co. continued to develop shallow wells good for 20 to 100 barrels of 34° oil initial production, and at the end of the year it had five wells in process of drilling.

Wildcat tests were started 6 miles north of Camarillo and 5 miles northeast of Somis.

SOUTHERN DIVISION.

Largely as a consequence of the rapid development of the Montebello field and the continued increase in the production of the Standard Murphy Coyote property, the southern California district increased in oil marketed and in relative importance as compared with the San Joaquin Valley fields. Indeed at the end of the year the Whittier-Fullerton district was only slightly behind the famous Midway-Sunset field in daily production, and judged by the amount of new drilling going on the southern field may be the foremost single field of the State by the end of another year.

During the year 106 oil wells were completed in southern California as against 70 in 1917, which gives an index to the remarkable increase in activity. At the end of the year 108 wells were being drilled in this district. The Coyote Hills and Montebello have been the most important fields in respect to amount of recent drilling, quantity

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of production, and increase in production. It was because of the increase over 1917 of more than 11,000,000 barrels in oil marketed from these two fields that California showed an increase instead of a decrease in production in 1918.

Los Angeles City and Salt Lake.—The Los Angeles City field is a distinctly old-age field, in which no new drilling took place. Because of scarcity of oil there was some talk of removing some of the city's restrictions against new operations in this field as a war measure. A few old abandoned wells were cleaned out and maintained a profitable production for a short time thereafter. Development was also practically at a standstill in the Salt Lake field, with only one new well during the year and a decline of 6.05 per cent in annual production.

Montebello.—Although only discovered in 1917 a very rapid development took place in the Montebello field during 1918, which brought the output up to 6,532,745 barrels for the year, an increase of 687.6 per cent over the output in 1917. Such activity was a natural outcome of the war demand for oil and the high initial production of wells in this field, which averaged more than 1,000 barrels initial production. Development has been so rapid that already the limits of proved territory are pretty well defined and the field will probably reach its peak of production within the next year or two.

Newhall.—During the year the Tunnel Petroleum Co. has brought in some small wells north of the old Ellsmere field, and the Buick Oil Co. has been drilling a wildcat well on the divide east of the Fernando tunnel.

Whittier-Fullerton.—Within this district, which comprises the most important fields of southern California (except Montebello), there was an increase in production of 1,036,683 barrels. This increase amounting to 6 per cent over the output of 1917, was made possible largely by the rapid development and splendid production obtained in the Coyote Hills, and particularly on the Standard Murphy property. Wells on this property, although over 4,000 feet deep, are now completed in a comparatively short time and with such satisfactory drilling methods that this field is one of those least affected by water. On the other hand the Union Oil Co. has just completed its fifth year of work on its Bastanchury lease adjacent to the Standard Murphy, and has spent a large amount of money without getting a successful well. This, despite the fact that oil is known to be present and several short flows of considerable volume were obtained from its deep tests. The difficulty has been largely to locate water and oil sands accurately and to shut off water successfully at a depth of over 4,500 feet. In the East Coyote Hills the Union has drilled several wells on its properties but has not done any great amount of development, apparently preferring to exploit shallower territory during the present pressure for oil.

The most active development in the old Whittier field has been on the Standard Murphy Whittier property, where this company has been active both in redrilling and on new wells.

In Brea Canyon the Birch, Fullerton, and Columbia Oil companies each completed a well during the year. These wells are all about 4,000 feet deep and were among the hardest and most expensive in the State to drill, but when completed are good for several hundred barrels initial production and are remarkably long-lived.

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In the Olinda field most of the new drilling was in the southernmost part of the field on the Union Naranjal and Stearns leases and on the West Coast Oil Co.'s lease.

MISCELLANEOUS WILDCAT TESTS.

LOS ANGELES COUNTY.

Whittier-Fullerton district.—Many tests in wildcat territory were made in this district, but the only successful one of the year was the Standard Kraemer No. 1 east, at Yorba Linda. This well came in in September at initial production of 200 to 350 barrels. Interest was immediately aroused in this district and all adjacent lands were leased and half a dozen other test wells were started before the end of the year. The geologic structure indicates that the field will be narrow and probably of only small areal extent.

The Mascot Oil Co. had a well drilling across the river east from Montebello field and a well on Rideau Heights a little to the south, both these wells being on the extreme west end of Whittier Hills. North of this is the Union Oil Co.'s El Monte, wildcat, and two wildcat wells of the Shell Co. are farther east between Montebello and the town of Puente. No conclusive results were obtained at any of these wells during the year.

The Copa d'Oro well, 3 miles north of the Brea Canyon field, was abandoned at a depth of nearly 4,000 feet. A show of oil was reported at 3,690 feet. About a mile farther north is the Currier well, also abandoned during the year after six years spent in drilling to a depth of about 4,000 feet. The Sentous test well of the Petroleum Development Co. (Santa Fe) northwest of Puente, was abandoned at 3,955 feet. A rig was erected toward the end of the year for a test in the Chino Hills south of Pomona. The Myers well of the Union Oil Co. east of Santa Fe Springs continued drilling below 4,300 feet. The Union Chapman well, about a mile northwest of Richfield, was drilling throughout the year and encountering much hard formation.

Near Los Angeles were several tests which were abandoned or had not struck oil during the year. The Mount Washington well, northwest of Los Angeles, continued drilling intermittently, below 2,000 feet.

East of Los Angeles was the Amalgamated Oil Co.'s Huntington well, in Boyle Heights, which got salt water at 3,030 feet and went to over 4,000 feet before being abandoned. The Jordan well, east of Eastlake Park, also failed to get any oil during the year but is still drilling.

Between Los Angeles and the sea three wells were abandoned and another test was started. The Union Bixby well, north of Long Beach, was abandoned early in the year because of mechanical trouble and poor outlook. The Highland Development Co.'s well near Dominguez was abandoned after prolonged efforts to shut off water and bring it in as a gas well, an upper gas sand having been encountered. The Bartolo Oil Co. abandoned its test southwest of Los Angeles, though the Standard Oil Co. started a well near by on its Baldwin lease, and was down to 2,500 feet by the end of the year.

In the San Fernando Valley the Luetge well, near Burbank, was abandoned at 1,800 feet. Farther west, southwest of San Fernando, the Standard Oil Co. started a test on the Sunshine ranch.

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ORANGE COUNTY.

Near Newport efforts were continued to develop a field and the Liberty Petroleum Co. brought in a well rated at as high as 150 barrels initial, of 12° Baumé oil at a depth of about 2,000 feet. The production soon fell off and water trouble as well as the viscosity of the oil made the well of doubtful value. Steam was used to heat the oil in the well in order to pump it. On the Irvine ranch, southwest of Santa Ana, the Standard Oil Co. started a test well which had reached a depth of about 3,500 feet by the end of the year.

SAN DIEGO COUNTY.

The test well of the Balboa Oil Co., near the city of San Diego, was abandoned at 5,700 feet. This is the deepest well in the State.

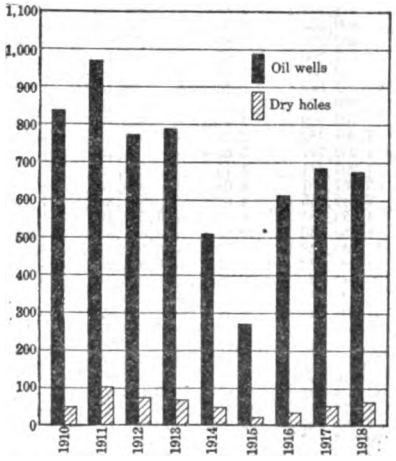

FIGURE 109.—Comparison of number of producing oil wells with dry holes drilled in California, 1910–1918.

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PETROLEUM PRODUCED.

Petroleum produced in California, 1876–1918.

Year.	Quantity (barrels).	Percentage of total production of United States.	Increase or decrease.		Value.	Yearly average price per barrel.
			Barrels.	Per cent.		
1876	12,000	0.13			$30,000	$2.500
1877	13,000	.10	+ 1,000	+ 8.33	32,500	2.500
1878	15,227	.10	+ 2,227	+ 17.13	35,174	2.309
1879	19,858	.10	+ 4,631	+ 30.41	45,872	2.310
1880	40,552	.15	+ 20,694	+104.21	93,675	2.309
1881	99,862	.36	+ 59,310	+146.26	230,727	2.310
1882	128,636	.42	+ 28,774	+ 28.81	297,149	2.309
1883	142,857	.61	+ 14,221	+ 11.06	330,000	2.310
1884	262,000	1.08	+ 119,143	+ 83.40	605,220	2.310
1885	325,000	1.49	+ 63,000	+ 24.46	750,750	2.310
1886	377,145	1.34	+ 52,145	+ 16.05	870,205	2.307
1887	678,572	2.39	+ 301,427	+ 79.92	1,567,501	2.310
1888	690,333	2.50	+ 11,761	+ 1.73	1,390,666	2.014
1889	303,220	.86	− 387,113	− 56.08	356,048	1.174
1890	307,360	.67	+ 4,140	+ 1.37	384,200	1.251
1891	323,600	.59	+ 16,240	+ 5.28	401,264	1.240
1892	385,049	.76	+ 61,449	+ 18.99	561,333	1.458
1893	470,179	.97	+ 85,130	+ 22.11	608,092	1.293
1894	705,969	1.43	+ 235,790	+ 50.15	823,423	1.166
1895	1,208,482	2.28	+ 502,513	+ 71.18	849,062	.703
1896	1,252,777	2.05	+ 44,295	+ 3.67	1,240,990	.991
1897	1,903,411	3.15	+ 650,634	+ 51.93	1,713,102	.900
1898	2,257,207	4.08	+ 353,796	+ 18.59	1,917,596	.850
1899	2,642,095	4.63	+ 384,888	+ 15.67	2,508,751	.950
1900	4,324,484	6.80	+ 1,682,389	+ 63.67	4,076,975	.943
1901	8,786,330	12.66	+ 4,461,846	+108.17	4,974,540	.566
1902	13,984,268	15.75	+ 5,197,938	+ 59.16	4,873,617	.348
1903	24,382,472	24.27	+10,398,204	+ 74.36	7,399,349	.303
1904	29,649,434	25.33	+ 5,266,962	+ 21.60	8,265,434	.279
1905	33,427,473	24.81	+ 3,778,039	+ 12.74	8,201,846	.245
1906	33,098,598	26.17	− 328,875	− .98	9,553,430	.289
1907	39,748,375	28.93	+ 6,649,777	+ 20.09	14,699,956	.370
1908	44,854,737	25.13	+ 5,106,362	+ 12.87	23,433,502	.523
1909	55,471,601	30.29	+10,616,864	+ 23.67	30,756,713	.554
1910	73,010,560	34.84	+17,538,959	+ 31.62	35,749,473	.490
1911	81,134,391	36.80	+ 8,123,831	+ 11.13	38,719,080	.477
1912	a87,272,593	39.15	+ 6,138,202	+ 7.57	39,624,501	.454
1913	97,788,525	39.356	+10,515,932	+ 12.05	45,709,400	.467
1914	99,775,327	37.54	+ 1,986,802	+ 2.03	48,066,096	.482
1915	86,591,535	30.81	−13,183,792	− 13.21	36,558,439	.422
1916	90,951,936	30.24	+ 4,360,401	+ 5.04	53,702,733	.590
1917	93,877,549	27.996	+ 2,925,613	+ 3.22	86,161,764	.918
1918	97,531,997	27.40	+ 3,654,448	+ 3.89	118,770,790	1.218
	1,110,226,576	24.09			636,940,958	.574

a Includes small quantity from Alaska.

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Petroleum produced in California in 1917 and 1918.

District and county.	1917			1918		
	Quantity (barrels).	Value.	Average price per barrel.	Quantity (barrels).	Value.	Average price per barrel.
California:						
Coastal and southern:						
Los Angeles County:						
Los Angeles City	261,348	$227,572	$0.871	268,025	$353,915	$1.320
Montebello	829,428	860,258	1.037	6,532,745	8,064,747	1.235
Newhall	121,879	132,557	1.088	114,789	152,076	1.325
Salt Lake	1,170,213	1,177,446	1.066	1,099,391	1,341,041	1.220
Coyote Hills, Puente, Whittier	2,156,655	2,066,484	.958	1,837,569	2,266,000	1.233
Orange County:						
Coyote Hills, Fullerton	14,515,060	14,021,289	.966	15,870,829	20,161,431	1.270
Ventura County:						
Santa Paula	963,422	1,044,904	1.084	1,328,983	1,861,463	1.401
Santa Barbara County:						
Cat Canyon, Lompoc, Casmalia, Santa Maria	4,801,065	4,193,557	.873	5,374,102	6,076,060	1.131
Summerland	47,036	42,673	.909	62,400	96,560	1.547
San Luis Obispo County, Santa Clara County	98,715	89,140	.903	83,419	100,572	1.206
	24,964,821	23,855,880	.956	32,572,252	40,473,865	1.242
San Joaquin Valley:						
Fresno County:						
Coalinga	15,984,766	14,211,319	.889	16,630,926	20,071,045	1.270
Kern County:						
Kern River	8,144,348	6,998,867	.859	7,500,237	8,629,899	1.151
Lost Hills	4,249,039	4,044,013	.951	3,590,605	4,520,550	1.259
McKittrick, Belridge	5,024,320	3,691,904	.734	4,815,610	5,126,692	1.065
Midway	28,829,674	27,095,565	.939	26,407,728	32,516,990	1.231
Sunset	6,680,581	6,264,216	.937	6,014,639	7,431,749	1.236
	68,912,728	62,305,884	.904	64,959,745	78,296,925	1.205
Grand total	93,877,549	86,161,764	.918	97,531,997	118,770,790	1.218

Petroleum produced in California, 1909–1918, by counties, in barrels.

Year.	Fresno.	Kern.	Los Angeles.	Orange.	Santa Barbara.	Ventura.	San Mateo.	Santa Clara.	Total.
1909	14,795,459	23,831,768		16,774,195			[a] 70,179		55,471,601
1910	18,387,750	37,896,727		16,665,678			[b] 60,405		73,010,560
1911	18,483,751	45,921,712		16,708,466			[b] 20,462		81,134,391
1912	19,911,820	50,245,255		[c] 17,095,395			[b] 20,123		87,272,593
1913	19,302,654	58,278,966		20,164,689			[b] 42,216		97,788,525
1914	15,692,733	62,429,243	3,150,892	13,260,226	4,363,797	857,685	[d] 20,751		99,775,327
1915	12,851,034	53,886,181	2,732,250	11,885,150	4,290,944	908,359	[d] 37,617		86,591,535
1916	14,231,251	55,325,669	3,839,724	12,095,819	4,481,842	932,028	[b] 45,603		90,951,936
1917	15,984,766	52,927,962	4,539,523	14,515,060	4,848,101	963,422	[b] 98,715		93,877,549
1918	16,630,926	48,328,819	9,852,519	15,870,829	5,436,502	1,328,983	[b] 83,419		97,531,997

[a] Includes oil produced in San Luis Obispo County.
[b] Production of Santa Clara and San Luis Obispo counties.
[c] Includes small quantity from Alaska.
[d] Includes Monterey County.

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Petroleum produced in California in 1917 and 1918, with increase or decrease.

District and county.	Quantity (barrels).		Increase or decrease.	
	1917	1918	Barrels.	Per cent.
Coastal and southern:				
Los Angeles County:				
Los Angeles City	261,348	268,025	+ 6,677	+ 2.55
Montebello	829,428	6,532,745	+5,703,317	+687.62
Newhall	121,879	114,789	— 7,090	— 5.82
Salt Lake	1,170,213	1,099,391	— 70,822	— 6.05
Coyote Hills	2,156,655	1,837,569	— 319,086	— 14.80
Puente				
Whittier				
Orange County:				
Coyote Hills	14,515,060	15,870,829	+1,355,769	+ 9.34
Fullerton				
Ventura County:				
Santa Paula	963,422	1,328,983	+ 365,561	+ 37.94
Santa Barbara County:				
Cat Canyon	4,801,065	5,874,102	+ 573,037	+ 11.94
Lompoc				
Casmalia				
Santa Maria				
Summerland	47,036	62,400	+ 15,364	+ 32.66
San Luis Obispo County	98,715	83,419	— 15,296	— 15.50
Santa Clara County				
San Joaquin Valley:				
Fresno County:				
Coalinga	15,984,766	16,630,926	+ 646,160	+ 4.04
Kern County:				
Kern River	8,144,348	7,500,237	— 644,111	— 7.91
Lost Hills	4,249,039	3,590,605	— 658,434	— 18.34
McKittrick	5,024,320	4,815,610	— 208,710	— 4.15
Belridge				
Midway	28,829,674	26,407,728	—2,421,946	— 8.40
Sunset	6,080,581	6,014,639	— 665,942	— 9.97
	52,927,962	48,328,819	—4,599,143	— 9.52
Grand total	93,877,549	97,531,997	+3,654,448	+ 3.89

Petroleum produced, value, and average price per barrel in California, 1909–1918.

Year.	Coastal and southern.			San Joaquin Valley.			Total.		
	Quantity (barrels).	Value.	Average price per barrel.	Quantity (barrels).	Value.	Average price per barrel.	Quantity (barrels).	Value.	Average price per barrel.
1909	16,844,374	$9,737,616	$0.578	38,627,227	$21,019,097	$0.544	55,471,601	$30,756,713	$0.554
1910	16,726,063	10,532,080	.629	56,284,477	25,217,393	.448	73,010,560	35,749,473	.490
1911	16,728,928	10,607,280	.904	64,405,463	28,111,800	.436	81,134,391	38,719,080	.477
1912	a17,115,518	a10,454,186	.615	70,157,075	29,170,315	.416	87,272,593	39,624,501	.454
1913	20,206,905	11,273,794	.557	77,581,620	34,435,606	.444	97,788,525	45,709,400	.467
1914	21,653,351	13,047,568	.603	78,121,976	35,018,528	.448	99,775,327	48,066,096	.482
1915	19,854,320	9,668,430	.486	66,737,215	26,890,009	.403	86,591,535	36,558,439	.422
1916	21,395,016	13,378,632	.625	69,556,920	40,324,101	.580	90,951,936	53,702,733	.590
1917	24,964,821	23,855,880	.956	68,912,728	62,305,884	.904	93,877,549	86,161,764	.918
1918	32,572,252	40,473,865	1.242	64,959,745	78,296,925	1.205	97,531,997	118,770,790	1.218

a Includes small quantities from Alaska.

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Oil Co. (

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FIELD REPORT.

Field report for oil industry in California in 1917 and 1918.

County and district.	Wells.					Acreage.		
	Productive Jan. 1.	Completed.		Abandoned.	Productive Dec. 31.	Fee.	Lease.	Total.
		Oil.	Dry.					
1917.								
Fresno County	1,109	104	4	27	1,186	20,465	23,571	44,036
Kern County:								
Kern River	1,857	39	2	3	1,893	11,688	5,304	16,992
Lost Hills	269	72	.....	3	338	10,568	2,181	12,749
McKittrick [a]	421	75	3	21	475	41,891	6,097	47,988
Midway	1,478	209	19	11	1,676	27,830	29,073	56,903
Sunset	420	64	2	12	472	3,595	1,900	5,495
Los Angeles County:								
Los Angeles City	378	.....	1	.....	378	29	21	50
Montebello	.....	7	.....	.....	7	34	1,554	1,588
Newhall-Puente	121	7	2	.....	128	4,968	396	5,364
Salt Lake	280	3	.....	.....	283	927	779	1,706
Coyote Hills, Whittier	160	13	2	2	171	2,688	1,367	4,055
Orange County	460	40	8	14	486	13,882	8,728	22,610
San Luis Obispo County	5	6	.....	.....	11	.....	1,706	1,706
Santa Clara County	7	.....	.....	.....	7	200	6,000	6,200
Santa Barbara County:								
Lompoc-Santa Maria [b]	308	27	2	5	330	40,882	42,864	83,746
Summerland	127	.....	.....	3	124	10	1	11
Ventura County	384	19	3	4	399	12,847	24,210	37,057
Miscellaneous	.....	1	.....	1	.....	.....	600	600
	7,784	686	48	106	8,364	192,504	156,352	348,856
1918.								
Fresno County	1,186	112	3	20	1,278	13,651	3,590	17,241
Kern County:								
Kern River	1,893	70	.....	7	1,956	11,973	4,995	16,968
Lost Hills	338	23	4	2	359	9,030	2,947	11,977
McKittrick [a]	475	51	9	2	524	45,020	2,629	47,649
Midway	1,676	153	14	11	1,818	27,556	21,946	49,502
Sunset	472	82	4	8	546	5,366	8,148	13,514
Los Angeles County:								
Los Angeles City	378	.....	.....	.....	378	28	55	83
Montebello	7	43	5	.....	50	9,750	5,784	15,534
Newhall-Puente	128	6	1	2	132	5,275	756	6,031
Salt Lake	283	1	.....	.....	284	1,052	640	1,692
Coyote Hills, Whittier	171	9	3	3	177	2,648	1,790	4,438
Orange County	486	47	4	5	528	14,581	10,495	25,076
San Luis Obispo County	11	4	.....	1	14	.....	1,420	1,420
Santa Clara County	7	.....	1	.....	7	.....	6,200	6,200
Santa Barbara County:								
Lompoc-Santa Maria [b]	330	41	9	8	363	96,656	27,965	124,621
Summerland	124	.....	.....	.....	124	10	1	11
Ventura County	399	34	4	3	430	82,578	19,615	102,193
Miscellaneous	.....	.....	2	.....	.....	.....	246	246
	8,364	676	63	72	8,968	325,174	119,222	444,396

[a] Includes Belridge.

[b] Includes Casmalia.

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OUTPUT OF REFINERIES.

The Bureau of Mines has published the following tables showing the essential statistics concerning the refining of crude oil in the United States in 1918.

Detail of oils run to refinery stills in 1918.

1918	Crude oil (barrels).	Other oils.				Total oils run (barrels).
		Purchased and rerun (barrels).	Own oils rerun (barrels).	Casing-head gasoline (barrels).	Total other oils (barrels).	
January	23,842,587	1,591,111	531,909	177,314	2,300,334	26,142,921
February	23,386,676	1,631,065	457,325	209,943	2,298,333	25,685,009
March	26,239,662	2,674,985	783,925	237,962	3,696,872	29,936,534
April	26,201,544	3,268,908	479,050	208,286	3,956,244	30,157,788
May	28,510,698	3,347,807	567,316	196,900	4,112,023	32,622,721
June	28,140,479	2,701,865	621,449	159,956	3,483,270	31,623,749
July	29,170,718	3,304,145	2,430,269	217,123	5,951,537	35,122,255
August	28,534,275	3,566,207	2,544,956	265,190	6,376,353	34,910,628
September	28,390,431	2,610,151	2,724,271	151,325	5,485,747	33,876,178
October	29,237,767	2,216,073	3,189,018	166,756	5,571,847	34,809,614
November	27,411,636	2,090,391	1,540,117	227,246	3,857,754	31,269,390
December	26,958,157	1,579,967	1,661,586	233,337	3,474,890	30,433,047
	326,024,630	30,582,675	17,531,191	2,451,338	50,565,204	376,589,834

Source of crude oil run to stills in December, 1918.

[In barrels of 42 gallons.]

Fields.	East Coast (New York, Philadelphia, and Baltimore).	Pennsylvania, New York, eastern Ohio, and West Virginia.	Western Ohio, Indiana, Illinois, Kentucky, and Tennessee.	Oklahoma and Kansas.	Texas and Louisiana.	Colorado and Wyoming.	California.	Total.
Appalachian	1,060,901	984,845	39,851					2,085,597
Lima and Indiana		38,579	122,553					161,132
Illinois	643,536	30,136	505,801					1,179,473
Oklahoma and Kansas	2,317,211	486,182	1,252,835	4,689,544	2,922,768			11,668,540
Central and northern Texas			3,396	280,766	1,568,949			1,853,111
North Louisiana					639,092			639,092
Gulf Coast	275,132				619,817			894,949
Colorado and Wyoming						1,091,873		1,091,873
California							5,469,097	5,469,097
Mexico	1,024,697				890,596			1,915,293
	5,321,477	1,539,742	1,924,436	4,970,310	6,641,222	1,091,873	5,469,097	26,958,157

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Output of refineries in the United States for the year 1918.

	Crude run (barrels).	Oils purchased and rerun (barrels).	Gasoline (gallons).	Kerosene (gallons).	Gas and fuel (gallons).	Lubricating (gallons).	Wax (pounds).	Coke (short tons).	Asphalt (short tons).	Miscellaneous (gallons).	Losses. (barrels).
East coast	64,119,528	7,330,083	718,720,111	485,559,229	1,118,998,731	257,412,655	215,791,443	222,644	270,172	78,617,550	3,631,988
Pennsylvania	18,804,510	1,992,336	241,639,462	136,951,334	201,775,157	182,864,252	86,432,928	19,758	2,900	36,308,371	1,187,926
Indiana and Illinois	22,184,148	7,987,413	460,795,843	187,070,255	344,497,236	97,460,092	78,020,865	137,759	71,942	43,476,748	1,890,377
Oklahoma and Kansas	60,805,183	9,378,896	865,799,574	415,222,396	1,344,145,229	109,876,505	48,726,352	56,659	10,434	68,125,325	2,525,447
Texas and Louisiana	81,733,167	5,579,957	636,856,670	435,281,246	1,934,441,119	123,258,451	73,145,391	107,931	145,887	352,028,239	3,019,166
Colorado and Wyoming	11,913,125	4,627,512	212,108,809	62,695,223	243,755,929	3,653,559	2,259,346	14,912	40	136,475,995	732,931
California	66,464,969	13,669,007	434,392,494	102,580,454	2,133,784,156	66,940,253	768,032	.....	106,593	571,678,155	1,568,790
Total, 1918	326,024,630	50,565,204	3,570,312,963	1,825,360,137	7,321,397,557	841,465,767	505,144,357	559,663	607,968	1,286,710,383	14,556,625
Total, 1917	315,131,681	[a] 14,897,670	2,850,546,423	1,726,768,976	6,513,324,280	753,776,840	481,200,081	539,366	739,425	702,167,243	13,073,829
Increase	10,892,949	.....	719,766,540	98,591,161	808,073,277	87,688,927	23,944,276	20,297	[b] 131,457	584,543,140	1,482,796
Daily average, 1918	893,218	138,535	9,781,679	5,000,987	20,058,623	2,305,386	1,383,957	1,533	1,666	3,525,234	39,881
Daily average, 1917	863,374	80,966	7,809,716	4,730,874	17,844,724	2,065,142	1,318,356	1,478	2,026	1,923,746	35,819
Increase	29,844	.....	1,971,963	270,113	2,213,899	240,244	65,601	55	[b] 360	1,601,488	4,062

[a] Total of last six months of 1917.

[b] Decrease.

Output of refineries in the United States, 1918, by months.

	Crude run (barrels).	Oils purchased and rerun (barrels).	Gasoline (gallons).	Kerosene (gallons).	Gas and fuel (gallons).	Lubricating (gallons).	Wax (pounds).	Coke (short tons).	Asphalt (short tons).	Miscellaneous (gallons).	Losses (barrels).
January	23,842,587	2,300,334	242,632,044	119,358,184	547,866,248	56,623,425	39,238,858	41,216	54,854	70,995,829	1,078,181
February	23,386,676	2,298,333	234,324,619	121,218,320	510,165,397	58,300,914	35,087,337	42,371	42,033	75,134,068	983,992
March	26,239,662	3,696,872	269,627,968	151,228,007	587,985,804	69,308,351	43,597,019	44,248	56,901	94,865,148	1,097,489
April	26,201,544	3,956,244	293,396,162	153,703,682	578,255,341	71,022,204	40,173,524	45,674	51,242	89,242,012	1,182,020
May	28,510,698	4,112,023	319,391,202	160,590,760	631,586,209	79,589,735	42,544,633	48,804	60,449	88,627,491	1,269,281
June	28,140,479	3,483,270	315,023,445	151,840,252	628,842,033	74,420,996	41,317,794	46,605	50,321	81,110,922	1,262,177
July	29,170,718	5,951,537	332,022,095	156,828,826	658,439,682	79,303,107	41,691,551	48,914	58,433	159,374,139	1,338,304
August	28,534,275	6,376,353	330,335,046	149,678,850	671,113,871	72,892,879	41,829,516	51,759	59,715	163,345,034	1,337,324
September	28,390,431	5,485,747	314,595,959	164,963,798	653,085,050	70,593,079	42,704,894	48,052	49,157	138,201,963	1,236,837
October	29,237,767	5,571,847	314,251,318	164,928,640	661,780,441	72,244,633	43,470,132	48,820	51,878	166,109,867	1,161,545
November	27,411,636	3,857,754	312,968,640	169,278,105	604,403,494	72,178,602	49,642,007	51,393	35,387	75,430,160	1,236,818
December	26,958,157	3,474,890	291,744,465	161,742,713	587,873,987	64,987,842	43,847,092	41,747	37,598	84,273,730	1,352,657
	326,024,630	50,565,204	3,570,312,963	1,825,360,137	7,321,397,557	841,465,767	505,144,357	559,663	607,968	1,286,710,383	14,556,625

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Detail of miscellaneous oils produced, 1918.

[Reported on Monthly Refinery Report under "Miscellaneous."]

	Gallons.		Gallons.
Binder	2,769,924	Motor spirits	56,491,689
Flux	52,381,776	Partly finished	375,738,962
Medicinal oils	1,483,790	Pitch	831,863
Mineral turpentine	891,442	Residuum	5,269,164
Paint	157,188	Slops	2,032,594
Petrolatum	5,688,557	Tar and acid oil	995,031
Road oil	42,197,035	Tops	85,912,133
Roofers' wax	109,119	Washout	25,983
Tar	847,263	Wax oil	2,185,496
Acid oil	911,402	Wax tailings	4,799,412
Distillate	585,338,667	Miscellaneous	59,152,235
Foots oil	151,315		
Motor fuel	348,343		1,286,710,383

Analysis of production and consumption of petroleum in United States in 1918.

	Gasoline.	Kerosene.	Gas and fuel.	Lubricating.
	Gallons.	*Gallons.*	*Gallons.*	*Gallons.*
Stocks, Dec. 31, 1917[a]	412,256,833	497,750,082	577,899,112	136,855,342
Production, 1918	3,570,312,963	1,825,360,137	7,321,397,557	841,465,767
	3,982,569,796	2,323,110,219	7,899,296,669	978,321,109
Exports	559,125,330	491,109,815	[b] 1,483,665,928	257,315,632
Shipments to our insular possessions	12,209,957	11,530,802	43,986,549	2,615,666
Domestic consumption	3,113,907,526	1,440,051,773	5,712,642,935	579,536,237
Stocks, Dec. 31, 1918	297,326,983	380,117,829	659,001,257	138,853,574
	3,982,569,796	2,323,110,219	7,899,296,669	978,321,109

[a] Figures on exports are taken from reports of the Bureau of Foreign and Domestic Commerce.
[b] Includes fuel or bunker oil for vessels engaged in foreign trade, 6,578,141 barrels.

IMPORTS.[1]

Despite the fact that the United States is the world's principal producer and distributor of petroleum and petroleum products, its import trade in those commodities is steadily increasing. This is especially true with regard to grades of oil desired for use as fuel, including both crude petroleum and "topped crude," from Mexico.

Petroleum, paraffin oil, and ozokerite and paraffin wax imported for consumption in the United States, 1914–1918.

Year.	Crude petroleum.		Paraffin.		Ozokerite and paraffin wax.		Total value.
	Quantity (barrels).	Value.	Quantity (barrels).	Value.	Quantity (pounds).	Value.	
1914	17,247,483	$11,465,466	2,481	$36,687	15,516,242	$824,234	$12,326,387
1915	18,140,110	10,389,012	1,707	85,121	10,259,445	553,397	11,027,530
1916	20,570,075	12,602,811	902	75,925	12,266,191	706,874	13,385,610
1917	30,162,583	16,400,017	93	3,514	10,608,099	729,210	17,132,741
1918	37,735,641	21,319,464	493	3,968	1,809,459	147,805	21,471,257

[1] Statistics of imports and exports were compiled by J. A. Dorsey, of the United States Geological Survey, from the records of the Bureau of Foreign and Domestic Commerce, Department of Commerce.

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Gross imports of petroleum and petroleum products into the United States in 1917 and 1918.

Kind and source.	1917		1918	
	Quantity.	Value.	Quantity.	Value.
Crude petroleum:	*Gallons.*		*Gallons.*	
Canada	1,627,124	$152,493	63,623	$7,229
Mexico	1,257,207,692	16,137,130	1,584,201,535	21,305,108
Cuba	4,804,060	57,454	630,001	7,001
Trinidad and Tobago	2,349,352	41,952	.....	.....
Other British West Indies	840,000	10,967	.....	.....
Dominican Republic	100	6	.....	.....
Peru	.....	.....	907	77
England	130	10	165	15
China	8	5	50	15
Japan	.....	.....	650	19
	1,266,828,466	16,400,017	1,584,896,931	21,319,464
Benzine, gasoline, and naphtha:				
Canada	69,108	7,307	147	61
Mexico	84	25	4,454,360	393,474
Honduras	1	2	.....	.....
Peru	10,425,281	1,403,946	8,444,843	1,528,360
England	10	6	.....	.....
France	135	167	.....	.....
	10,494,619	1,411,453	12,899,350	1,921,895
All other refined:				
Canada	3,168,579	314,911	1,014,490	150,227
Mexico	43,643,195	2,472,035	36,784,556	2,277,231
Trinidad and Tobago	150	10	.....	.....
Argentina	2,450	2,071	.....	.....
Colombia	.....	.....	13	5
Peru	.....	.....	72	13
Venezuela	.....	.....	250	12
England	20,312	4,598	384	668
France	29	58	.....	.....
China	5	2	160	20
Japan	10	16	850	200
Australia	.....	.....	89	60
	46,834,730	2,793,701	37,800,864	2,428,436
Mineral wax (ozokerite and ceresine):	*Pounds.*		*Pounds.*	
Canada	54,682	4,398	147,005	19,787
Mexico	.....	.....	10	4
England	247,582	36,014	4,844	1,233
Japan	170,001	19,880	.....	.....
British India	366,660	25,290	1,657,600	126,781
Straits Settlements	60,480	4,928	.....	.....
	899,405	90,510	1,809,459	147,805
Paraffin wax:				
Canada	1,995,888	135,893	667,646	77,280
Colombia	.....	.....	41,000	7,370
England	251,479	22,843	.....	.....
China	145	11	448,000	53,760
British India	2,535,666	182,212	.....	.....
Japan	62,720	4,411	2,000,230	229,433
Dutch East Indies	4,862,796	293,330	2,490,242	194,538
	9,708,694	638,700	5,647,118	562,386

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EXPORTS.

TERRITORIAL SHIPMENTS.

The demand for petroleum and its products from the United States in Alaska, Hawaii, Philippine Islands, and Porto Rico is indicated in the following summary:

Petroleum products shipped to Alaska from other parts of the United States, 1909–1918.

Year.	Oil used for fuel, including crude, gas oil, and residuum.		Gasoline, including all lighter products of distillation.		Illuminating.		Lubricating.	
	Quantity (gallons).	Value.	Quantity (gallons).	Value.	Quantity (gallons).	Value.	Quantity (gallons).	Value.
1909	14,119,102	$340,225	746,930	$118,810	531,727	$98,786	85,687	$35,882
1910	19,143,091	506,200	788,154	136,569	626,972	95,483	104,512	38,625
1911	20,878,843	485,279	1,238,865	167,915	423,750	57,896	100,141	34,048
1912	15,523,555	309,804	2,736,739	344,739	672,176	100,722	154,565	60,949
1913	15,682,412	453,756	1,735,658	272,661	661,656	106,603	150,918	61,966
1914	18,601,384	404,349	2,878,723	373,607	731,146	103,779	191,878	74,535
1915	16,910,012	476,564	2,413,962	243,712	513,075	82,105	271,981	101,988
1916	23,555,811	657,976	2,844,801	378,267	732,969	108,174	373,046	132,902
1917	23,971,114	1,014,100	3,256,870	501,867	750,238	106,619	465,693	171,638
1918	24,379,566	1,296,188	1,086,852	263,425	382,186	65,383	362,413	150,745

Petroleum products shipped to Hawaii, the Philippines, and Porto Rico, 1909–1918.

Year.	Oil used for fuel, including crude, gas oil, and residuum.		Gasoline, including all lighter products of distillation.		Illuminating.		Lubricating.	
	Quantity (gallons).	Value.	Quantity (gallons).	Value.	Quantity (gallons).	Value.	Quantity (gallons).	Value.
HAWAII.								
1909	43,764,041	$871,485	804,169	$127,076	1,401,381	$232,340	367,831	$121,282
1910	54,539,511	1,095,549	974,268	160,700	1,359,671	226,481	359,528	133,968
1911	47,250,018	949,409	1,329,589	203,052	1,587,873	220,505	466,826	138,927
1912	58,790,343	1,182,230	2,501,938	343,062	1,817,718	190,939	477,012	165,993
1913	60,066,083	1,154,188	2,058,091	315,333	1,807,288	210,997	456,477	145,455
1914	67,893,460	1,207,036	3,162,667	364,260	2,157,021	250,158	408,606	147,243
1915	72,795,931	1,256,003	3,546,351	379,134	1,966,448	227,212	569,032	193,821
1916	67,771,683	1,397,398	5,136,021	803,461	1,842,793	232,216	612,938	197,496
1917	69,196,370	1,999,120	6,942,835	1,160,008	2,563,754	314,197	905,700	303,267
1918	60,661,670	2,376,263	5,553,924	995,679	3,177,928	363,183	737,831	304,158
PHILIPPINES.								
1909	21,789	1,581	184,390	23,428	5,995,090	558,642	362,068	81,278
1910	13,703	1,122	318,070	42,058	10,643,804	862,496	432,867	95,213
1911	5,502	376	1,074,615	158,592	11,653,570	913,760	470,852	107,499
1912	106,872	5,358	1,326,040	216,810	12,634,519	1,094,596	487,607	121,999
1913	10,370	1,013	1,414,225	280,690	12,091,810	1,142,403	517,494	105,001
1914	11,408	564	1,197,774	206,754	12,906,403	1,219,404	971,977	189,279
1915	12,427	366	1,483,534	241,273	8,524,833	731,026	784,192	157,925
1916	14,819	528	3,226,026	631,541	8,539,700	809,014	635,329	148,443
1917	21,659	1,857	1,564,199	357,156	6,252,140	663,741	553,628	170,628
1918	2,500	156	2,702,996	709,657	6,495,910	1,004,612	1,014,943	320,519
PORTO RICO.								
1909	7,566	475	495,367	93,649	1,931,676	216,316	218,829	78,963
1910	8,739	499	874,814	135,290	1,973,369	222,108	238,935	91,356
1911	51,656	2,899	1,106,327	133,470	2,323,401	207,804	479,579	117,034
1912	29,204	1,857	1,470,105	223,325	2,168,105	212,043	471,596	134,882
1913	21,108	1,439	1,580,772	303,012	2,381,187	246,137	507,412	120,007
1914	53,586	4,939	1,836,896	320,163	2,227,195	227,500	361,117	80,247
1915	65,447	3,337	2,401,695	449,044	2,426,133	219,148	391,245	88,061
1916	182,722	7,428	2,811,843	727,466	2,168,208	207,976	521,092	119,121
1917	239,199	17,347	3,154,196	768,862	2,769,066	323,226	608,214	202,368
1918	232,820	13,743	2,866,185	967,002	1,774,783	324,327	500,489	239,461

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FOREIGN SHIPMENTS.

Mineral oils exported from the United States in 1917 and 1918, by months.

Month.	1917		1918	
	Quantity (gallons).	Value.	Quantity (gallons).	Value.
January	278,996,519	$20,701,353	227,660,562	$26,492,674
February	158,491,237	13,114,334	221,579,890	24,031,982
March	210,110,702	16,739,617	210,949,885	29,099,844
April	200,261,380	19,481,880	227,988,969	25,689,393
May	213,449,444	22,189,419	239,515,961	31,225,541
June	264,737,392	27,342,036	224,269,286	28,380,780
July	143,908,673	14,055,530	236,777,600	29,630,024
August	225,487,195	21,307,362	237,979,571	32,919,914
September	200,687,535	16,809,054	263,841,757	30,304,963
October	222,775,688	22,131,313	217,970,785	26,525,277
November	231,835,757	29,931,671	219,157,629	30,937,693
December	300,286,827	29,173,907	186,927,851	29,027,415
	2,651,118,349	252,977,476	2,714,619,746	344,265,500

Mineral oils exported from the United States in 1917 and 1918, by kinds and districts.

Kind and district.	1917		1918	
	Quantity.	Value.	Quantity.	Value.
CRUDE.	*Barrels.*		*Barrels.*	
New York	111,644	$675,623	102,739	$740,553
Galveston	12	51		
Sabine	5,828	19,581	92,183	508,448
Other districts	3,980,640	6,973,057	4,705,769	10,835,249
	4,098,124	7,668,312	4,900,691	12,084,250
GASOLINE AND NAPHTHA.	*Gallons.*		*Gallons.*	
Baltimore	581,042	150,569	18,510	3,861
Boston and Charlestown	128,439	35,614	116,426	30,723
New York	179,420,961	42,328,577	232,347,036	61,061,854
Philadelphia	100,601,279	22,433,561	153,026,585	38,345,431
Galveston	1,409,116	253,644		
Sabine	27,741,447	4,630,545	58,939,525	13,980,338
Other districts	105,996,560	23,292,734	114,920,773	26,171,533
	415,878,844	93,134,244	559,368,855	139,593,740
ILLUMINATING.				
Baltimore	4,042,761	344,296	527,484	90,472
Boston and Charlestown	219,056	26,831	175,097	35,516
New York	357,116,450	29,447,061	274,315,881	30,947,453
Philadelphia	83,782,461	5,643,580	60,964,932	5,382,284
Galveston	1,381,998	95,545		
Sabine	71,543,928	4,891,239	65,519,197	5,726,644
Other districts	140,069,833	8,505,058	89,607,224	8,172,045
	658,156,487	48,953,610	491,109,815	50,354,414
LUBRICATING AND PARAFFIN.				
Baltimore	9,523,410	1,937,522	6,934,940	2,063,619
Boston and Charlestown	317,405	68,497	1,320,884	430,340
New York	180,136,494	38,563,065	145,895,793	45,261,137
Philadelphia	70,793,039	12,998,815	70,009,944	18,441,353
Galveston	329,033	61,864	1,429,780	435,432
Sabine	2,636,855	543,118	2,800,000	1,117,376
Other districts	16,701,427	3,391,983	28,925,912	7,853,798
	280,437,663	57,564,864	257,317,253	75,603,055

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Mineral oils exported from the United States in 1917 and 1918, by kinds and districts—Con.

Kind and district.	1917		1918	
	Quantity.	Value.	Quantity.	Value.
GAS OIL AND FUEL OIL.[a]	*Gallons.*		*Gallons.*	
Baltimore	1,464,411	$952,028	15,825,126	$993,263
Boston and Charlestown	12,278,530	733,879	8,749,967	729,787
New York	121,194,441	7,555,069	203,725,272	14,192,780
Philadelphia	82,056,333	6,269,047	101,427,853	8,132,843
Galveston	9,270,239	279,062	17,020,722	633,905
Sabine	552,670,300	18,285,334	431,919,591	22,456,973
Other districts	344,538,793	11,474,863	422,081,788	19,476,192
	1,123,473,047	45,549,282	1,200,750,319	66,615,743
RESIDUUM.				
New York	356,632	23,839	24,556	2,924
Galveston	300	25		
Sabine	100	7	144	20
Other districts	694,081	83,293	219,774	11,354
	1,051,113	107,164	244,474	14,298
Grand total (gallons)	2,651,118,349	252,977,476	2,714,619,746	344,265,500

[a] Excludes fuel or bunker oil in vessels engaged in the foreign trade, which aggregated in 1917, 5,908,319 barrels, valued at $7,391,985, and in 1918, 6,603,043 barrels, valued at $11,676,053.

Recapitulation by kinds.

	1917		1918	
	Quantity.	Value.	Quantity.	Value.
	Gallons.		*Gallons.*	
Crude	172,121,195	$7,668,312	205,829,030	$12,084,250
Gasoline and naphtha	415,878,844	93,134,244	559,368,855	139,593,740
Illuminating	658,156,487	48,953,610	491,109,815	50,354,414
Lubricating and paraffin	280,437,663	57,564,864	257,317,253	75,603,055
Gas oil and fuel oil [a]	1,123,473,047	45,549,282	1,200,750,319	66,615,743
Residuum	1,051,113	107,164	244,474	14,298
	2,651,118,349	252,977,476	2,714,619,746	344,265,500

[a] Excludes fuel or bunker oil in vessels engaged in the foreign trade, which aggregated in 1917, 5,908,319 barrels, valued at $7,391,985, and in 1918, 6,603,043 barrels, valued at $11,676,053.

Recapitulation by districts.

	1917		1918	
	Quantity.	Value.	Quantity.	Value.
	Gallons.		*Gallons.*	
Baltimore	15,611,624	$3,384,415	23,306,060	$3,151,215
Boston and Charlestown	12,943,430	864,821	10,362,374	1,226,366
New York	842,914,025	118,593,227	860,623,563	152,206,701
Philadelphia	337,233,112	47,345,006	385,429,314	70,301,911
Galveston	12,391,186	690,196	18,450,502	1,099,337
Sabine	654,837,390	28,378,824	563,050,140	43,789,799
Other districts	775,187,582	53,720,988	853,397,793	72,520,171
	2,651,118,349	252,977,476	2,714,619,746	344,265,500

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Mineral oils exported from the United States in 1917 and 1918, by kinds and destinations.

Kind and destination.	1917		1918	
	Quantity.	Value.	Quantity.	Value.
CRUDE.				
North America:	*Barrels.*		*Barrels.*	
Canada	3,329,356	$5,117,148	4,395,201	$9,698,690
Mexico	47,725	81,998	52,209	90,866
Panama	41,730	92,224		
Cuba	262,631	1,087,635	204,609	1,031,091
South America:				
Chile	56,245	68,973	439	2,568
Europe:				
France	7,902	33,000		
Spain	58,622	410,996	92,597	696,236
Other Europe	7,591	14,865	24,666	66,637
Other countries	286,322	761,473	130,970	498,162
	4,093,124	7,668,312	4,900,691	12,084,250
REFINED.				
Gasoline.				
North America:	*Gallons.*		*Gallons.*	
Canada	27,647,086	4,861,883	26,093,644	4,932,199
South America:				
Argentina	4,398,606	801,251	1,870,540	689,239
Brazil	6,990,302	1,750,144	3,746,373	1,180,083
Europe:				
France	56,066,313	12,309,772	104,667,824	24,698,692
Italy	30,686,430	7,078,676	49,603,064	12,178,842
Netherlands	1,106,642	237,787		
United Kingdom	54,574,416	11,287,816	121,294,920	28,718,109
Other Europe	5,752,850	1,272,232	5,568,429	1,666,782
British Oceania	15,655,165	3,893,139	18,818,834	5,519,270
Other countries	21,933,681	5,556,947	20,303,536	5,642,358
	224,811,491	49,049,647	351,967,164	85,225,574
Naphtha.				
All countries	191,067,353	44,084,597	207,401,691	54,368,166
	415,878,844	93,134,244	559,368,855	139,593,740
Illuminating oil.				
North America:				
Canada	17,395,638	1,134,356	6,086,108	679,325
Cuba	1,082,739	159,974	5,788,038	965,119
West Indies	6,913,092	900,899	5,046,925	905,456
South America:				
Argentina	13,064,881	1,650,075	7,739,534	1,415,284
Brazil	30,817,597	3,235,151	12,406,067	2,047,125
Chile	6,757,639	823,876	5,640,956	974,938
Other South America	9,184,554	1,114,556	5,762,376	1,048,780
Europe:				
Denmark	8,818,250	473,404	4,917,138	747,259
France	73,948,069	4,382,741	78,491,864	6,578,459
Italy	31,137,116	1,875,858	25,952,679	2,082,153
Netherlands	17,796,759	966,189		
Sweden	11,439,719	666,925	9,454,014	1,440,537
United Kingdom	171,313,137	11,219,437	163,549,730	12,779,922
Other Europe	36,686,214	1,802,875	25,379,863	3,054,107
Asia:				
China	68,949,092	4,478,846	43,458,543	3,016,026
British India	29,485,437	2,120,559	8,170,457	893,396
Hongkong	14,090,907	911,126	8,479,016	605,371
Japan	20,488,540	1,336,012	16,219,296	1,542,772
Oceania:				
Dutch East Indies	11,702,690	1,258,875	2,365,000	405,825
British Oceania	19,990,057	2,077,704	18,328,887	2,154,082
Philippine Islands	6,252,140	663,741	6,495,910	1,004,612
British Africa	7,146,088	860,863	10,761,375	1,121,517
Other countries	43,696,132	4,839,569	20,671,039	4,892,349
	658,156,487	48,953,610	491,109,815	50,354,414

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Mineral oils exported from the United States in 1917 and 1918, by kinds and destination—Continued.

Kind and destination.	1917		1918	
	Quantity.	Value.	Quantity.	Value.
REFINED—continued.				
Lubricating and paraffin oil.				
North America:	*Gallons.*		*Gallons.*	
Canada	7,745,713	$1,713,032	7,009,174	$2,093,598
Mexico	644,201	189,058	894,576	321,935
Cuba	3,352,880	1,146,344	3,320,172	1,431,731
South America:				
Argentina	5,770,002	1,667,441	5,477,823	2,138,912
Brazil	4,833,617	1,222,482	3,326,766	1,233,474
Chile	2,556,557	634,677	3,847,413	1,203,441
Europe:				
France	71,687,467	14,452,685	43,886,076	11,687,153
Italy	20,067,146	3,795,289	17,137,330	5,327,510
Netherlands	534,296	112,295	7,500	2,550
United Kingdom	111,647,001	22,347,881	114,043,663	32,255,415
Other Europe	9,117,264	1,835,210	7,419,966	2,508,075
Asia:				
Japan	4,264,920	758,807	8,348,113	2,530,934
Oceania:				
British East Indies	13,308,716	2,244,394	12,483,183	3,050,756
British Oceania	6,725,247	1,440,621	12,075,669	3,567,928
British Africa	4,360,474	966,332	3,943,573	1,599,718
Other countries	13,822,262	3,038,316	14,096,256	4,649,925
	280,437,663	57,564,864	257,317,253	75,603,055
Gas oil and fuel oil.[a]				
All countries	1,123,473,047	45,549,282	1,200,750,319	66,615,743
Residuum, including tar.				
All countries	1,051,113	107,164	244,474	14,298
Total refined	2,478,997,154	245,309,164	2,508,790,716	332,181,250
Total crude and refined (gallons)	2,651,118,349	252,977,476	2,714,619,746	344,265,500

[a] Excludes fuel or bunker oil in vessels engaged in the foreign trade, which aggregated in 1917, 5,908,319 barrels, valued at $7,391,985, and in 1918, 6,603,043 barrels, valued at $11,676,053.

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Crude petroleum produced in the United States and petroleum products exported, 1909–1918.

Year.	Quantity produced.		Exports.											
			Mineral, crude (including all natural oils, without regard to gravity).		Mineral, refined or manufactured. Naphtha, benzine, gasoline, etc.		Illuminating.		Lubricating (heavy paraffin, etc.).		Residuum (tar, pitch, and all other from which the light bodies have been distilled).		Total.	
	Barrels of 42 gallons.	Gallons.	Quantity (gallons).	Value.	Quantity (gallons).	Value.	Quantity (gallons).	Value.	Quantity (gallons).	Value.	Quantity (gallons).	Value.	Quantity (gallons).	Value.
1909	183,170,874	7,693,176,708	170,337,773	$6,027,588	68,758,675	$5,799,994	1,046,401,072	$67,814,406	161,639,609	$20,016,107	121,966,249	$4,180,495	1,569,103,378	$108,338,590
1910	209,557,248	8,801,404,416	180,111,166	5,404,253	100,695,382	8,407,102	940,247,039	55,642,368	163,832,544	20,921,103	117,605,802	3,732,196	1,502,491,933	94,107,022
1911	220,449,391	9,258,874,422	201,843,355	6,165,403	137,294,606	11,432,761	1,112,295,006	61,055,095	183,319,645	23,337,120	133,979,087	3,882,463	1,768,731,699	105,922,848
1912	222,935,044	9,363,271,848	188,711,420	6,770,484	186,000,094	20,459,378	1,026,138,239	62,084,022	216,393,206	28,297,467	266,236,938	6,599,031	1,883,479,897	124,210,382
1913	248,446,230	10,434,741,660	194,469,634	8,448,294	188,043,379	28,091,608	1,119,441,243	72,042,107	207,639,092	29,608,549	426,872,373	11,125,851	2,136,465,721	149,316,409
1914	265,762,535	11,162,026,470	124,735,553	4,958,838	209,692,655	25,288,414	1,010,449,253	64,112,772	191,647,570	26,316,813	703,508,021	19,224,250	2,240,033,652	139,900,587
1915	281,104,104	11,806,372,368	158,263,069	4,282,827	281,609,081	33,885,047	836,958,665	49,988,597	239,678,725	32,459,641	812,216,209	22,525,557	2,328,725,749	142,941,669
1916	300,767,158	12,632,220,636	172,027,903	7,029,923	355,870,283	68,660,881	854,688,404	55,862,906	260,805,939	43,027,371	964,089,837	27,140,210	2,607,482,366	201,721,291
1917	335,315,601	14,083,255,242	172,121,195	7,668,312	415,878,844	93,134,244	658,156,487	48,953,610	280,437,663	57,564,864	1,124,524,160	45,656,444	2,651,118,349	252,977,476
1918	355,927,716	14,948,964,072	205,829,030	12,084,250	559,368,855	139,593,740	491,109,815	50,354,414	257,317,253	75,603,055	1,200,994,793	66,630,041	2,714,619,746	344,265,500

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Petroleum exported from Texas in 1917 and 1918.

1917.

Customs district.	Crude, including all natural oils.			Gasoline and naphtha.		Illuminating.		Lubricating and heavy paraffin.		Gas oil, fuel oil, and residuum.		Total.	
	Quantity.		Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Barrels.	*Gallons.*		*Gallons.*		*Gallons.*		*Gallons.*		*Gallons.*		*Gallons.*	
Laredo	19	810	$51	165,466	$48,747	36,038	$6,442	[a] 82,496	[a] $25,056	33,093	$1,833	317,903	$82,129
Galveston	12	500	51	1,409,116	253,644	1,381,998	95,545	329,033	61,864	9,270,539	279,092	12,391,186	690,196
Sabine	5,828	244,760	19,581	27,741,447	4,639,545	71,543,928	4,891,239	2,636,855	543,118	552,670,406	18,285,341	654,837,396	28,378,824
El Paso	4,500	188,996	7,576	98,806	26,868	91,195	15,356	30,883	9,900	96,100	4,179	505,980	63,879
Eagle Pass	.....	.....	.....	22,046	5,325	28,906	3,475	13,980	3,575	.....	.....	64,932	12,375
	10,359	435,066	27,259	29,436,881	4,974,129	73,082,065	5,012,057	3,093,247	643,513	562,070,138	18,570,445	668,117,397	29,227,403

1918.

San Antonio[b]	92	3,838	$342	45,928	$11,925	31,533	$5,249	131,270	$41,643	72,519	$3,093	285,088	$62,252
Galveston	.....	.....	.....	.....	.....	.....	.....	1,429,780	435,432	17,020,722	633,905	18,450,502	1,069,337
Sabine	92,183	3,871,683	508,448	58,939,525	13,980,338	65,519,197	5,726,644	2,800,000	1,117,376	431,919,735	22,456,993	563,050,140	43,789,799
El Paso	190	8,000	491	29,622	9,436	19,755	5,475	22,592	7,042	88,531	6,093	168,500	28,537
	92,465	3,883,521	509,281	59,015,075	14,001,699	65,570,485	5,737,368	4,383,642	1,601,493	449,101,507	23,100,084	581,954,230	44,949,925

[a] Includes 950 gallons of paraffin oil, valued at $165.

[b] Includes Laredo and Eagle Pass.

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Crude petroleum exported from Pacific ports, including shipments to noncontiguous territories, 1917–18.

Customs district.	1917		1918	
	Quantity (barrels).	Value.	Quantity (barrels).	Value.
From—				
Alaska	6,492	$11,042	(a)	(a)
Southern California	590,700	773,815	1,677	$3,390
Washington	35,642	49,657	1,473	2,673
Oregon	29	132	.....	.....
San Francisco	1,680,702	2,004,182	87	589
	2,313,565	2,838,828	3,237	6,652
To—				
Alaska	482,218	635,480	(a)	(a)
Canada	85,203	104,063	1,473	2,673
Chile	56,000	67,200	68	471
Hawaii	1,686,784	2,027,508	(a)	(a)
Mexico	3,289	4,400	1,677	3,390
Salvador	.....	.....	9	60
Other	71	177	10	58
	2,313,565	2,838,828	3,237	6,652

a Not available.

Mineral oils exported from the United States in 1918, by months.

Month.	Crude.		Gasoline and naphtha.		Illuminating.	
	Quantity (gallons).	Value.	Quantity (gallons).	Value.	Quantity (gallons).	Value.
January	17,217,709	$915,830	41,074,520	$10,135,181	57,210,212	$5,097,094
February	19,734,996	1,005,760	35,396,038	8,426,107	29,878,381	3,262,420
March	8,787,165	576,639	46,885,000	12,152,117	49,048,642	4,943,369
April	16,157,468	830,259	46,857,293	11,280,216	50,347,085	4,281,504
May	17,374,048	967,586	54,780,414	13,761,318	34,516,749	3,671,365
June	23,697,244	1,346,301	48,962,811	12,099,289	31,929,708	3,188,636
July	20,027,967	1,263,926	46,720,802	11,943,248	30,923,154	3,685,582
August	9,553,294	560,642	55,168,116	13,544,509	38,885,720	4,453,909
September	21,525,770	1,265,096	44,745,626	10,868,214	42,415,740	4,406,887
October	28,426,890	1,750,843	36,562,139	10,009,079	34,550,610	3,604,255
November	9,492,589	631,099	47,684,216	12,220,798	51,097,986	5,024,920
December	13,833,890	970,269	54,531,880	13,103,664	40,305,828	4,734,473
	205,829,030	12,084,250	559,368,855	139,593,740	491,109,815	50,354,414

Month.	Lubricating.				Fuel oil and gas oil.	
	Paraffin.		All other.			
	Quantity (gallons).	Value.	Quantity (gallons).	Value.	Quantity (gallons).	Value.
January	98,326	$20,146	18,749,405	$4,691,629	93,261,388	$5,580,282
February	1,350,403	308,955	16,356,634	4,517,404	118,817,732	6,509,639
March	202,189	57,284	25,553,769	7,267,266	80,439,180	4,098,929
April	1,773,914	395,876	14,410,321	4,085,348	98,442,761	4,816,162
May	341,609	91,724	25,275,578	6,801,535	107,173,728	5,929,777
June	244,376	65,010	23,746,554	6,403,087	95,668,043	5,276,942
July	241,676	84,200	19,604,322	6,064,831	119,259,679	6,588,237
August	499,656	137,135	27,308,319	8,640,784	106,546,198	5,582,268
September	236,218	64,941	18,353,993	6,309,768	136,551,883	7,389,030
October	1,980,289	197,383	17,255,327	5,407,368	99,185,641	5,556,052
November	49,053	17,307	24,737,540	7,673,247	86,095,745	5,370,267
December	41,412	14,366	18,906,370	6,286,461	59,308,341	3,918,158
	7,059,121	1,454,327	250,258,132	74,148,728	1,200,750,319	66,615,743

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Mineral oils exported from the United States in 1918, by months—Continued.

Month.	Residuum.		Total.	
	Quantity (gallons).	Value.	Quantity (gallons).	Value.
January	49,002	$2,512	227,660,562	$26,492,674
February	45,706	1,697	221,579,890	24,081,982
March	33,940	4,240	240,949,885	29,089,844
April	127	28	227,988,969	25,689,393
May	53,635	2,286	239,515,961	31,225,541
June	20,550	1,515	234,269,286	28,380,780
July			236,777,000	29,690,024
August	18,268	667	237,979,571	32,919,914
September	12,527	1,027	263,841,757	30,304,963
October	9,889	297	217,970,785	26,525,277
November	500	55	219,157,629	30,937,698
December	130	24	186,927,851	29,027,415
	244,474	14,298	2,714,619,746	344,365,500

PRICES.

The following tables, compiled from weekly quotations in the Oil, Paint, and Drug Reporter (New York), show the fluctuations in export price of the principal kinds of illuminating oil and of gasoline entering the foreign trade and, for comparison, the wholesale price of the same products to domestic jobbers in New York. The quotations on illuminating oil are for 150° F. fire test, water-white kerosene, and on gasoline for 68° to 72° Baumé auto naphtha. Quotations on standard white kerosene ranged 1 cent lower in price than quotations on the water-white grade.

Prices of illuminating oil at New York, 1917 and 1918.

Export price (cents per gallon).				Jobbing price (cents per gallon).		
Date.	Bulk.	Cases.	Barrels.	Date.	Tank wagon.	Barrels.
1917.				**1917.**		
Jan. 1	5.50	12.75	9.65	Jan. 1	11.00	12.00
Jan. 10	5.75	13.00	9.90	Aug. 6		13.00
Jan. 12	6.00	13.25	10.15	Nov. 10		14.00
Feb. 6			10.75	Dec. 8		15.00
Mar. 7	6.25	13.50	11.00	Dec. 19		16.00
Mar. 12	6.50	13.75	11.25			
July 9			11.35			
July 19		14.25				
Aug. 1		15.25				
Aug. 6		15.75				
Sept. 30		16.50				
Oct. 17			11.45			
Nov. 3			12.15			
Nov. 26	7.50	17.50	13.15			
Dec. 14			13.50			
1918.				**1918.**		
Jan. 21		17.75		Apr. 10		17.60
Feb. 27			13.70	July 22	11.50	17.50
Apr. 3			13.90			
Apr. 12			14.30			
May 17		18.00				
May 27	9.25	19.75	16.05			
July 22			16.50			
Oct. 31			18.25			
Dec. 28		20.25				

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Prices of gasoline at New York, 1917 and 1918.

Export price (cents per gallon).			Jobbing price (cents per gallon).		
Date.	10-gallon drum (less than 100 cases).	Cans and cases (less than 100).	Date.	Wooden barrels.	Auto naphtha, to garages only (steel barrels).
1917.			**1917.**		
Jan. 1	38.00	33.25	Jan. 1	31.00-32.00	22.00
Jan. 10	39.00	34.25	Feb. 3	32.00-33.00	23.00
May 24	41.00	36.25	Mar. 1	33.00-34.00	24.00
July 19	41.50	36.75	Aug. 11	34.00-35.00	.....
Aug. 1	.....	37.75			
Aug. 6	.....	38.25			
Aug. 21	43.75	.....			
Sept. 20	.....	39.00			
Nov. 26	51.25	.....			
1918.			**1918.**		
Jan. 21	.....	39.15	Apr. 1	35.00-36.00	.....
May 17	52.25	40.15	Apr. 10	36.00-37.00	.....
May 31	(a)	(a)	July 22	36.50-37.50	24.50

a All gasoline and naphtha prices for export withdrawn.

FUEL OIL.

GENERAL STATEMENT.

Complete statistics of fuel oil are not available. Data compiled by the Bureau of Mines show that 174,318,989 barrels of fuel oil and gas oil were produced by refiners of crude petroleum in the United States in 1918 and that refinery stocks of those products increased 1,931,006 barrels during the year. Reports of pipe-line and producing companies show that 43,241,316 barrels of crude petroleum were delivered for use as fuel. Records of the Bureau of Foreign and Domestic Commerce show that 37,735,641 barrels of petroleum, the greater part of which was used for fuel, was imported, chiefly from Mexico, in 1918 and that 33,495,806 barrels of crude oil, gas oil, fuel oil, and residuum were exported from the United States in the same period.

The fuel oil utilized in the United States consists in greater part of topped or semirefined petroleum of asphlatic or semiasphaltic base, though limited quantities of low-grade crude petroleum of asphaltic base and of the refining residuals of petroleum of paraffin base are also used. Because of the development of successful methods of refining by which ever-increasing proportions of the lower-grade products of petroleum distillation are converted into gasoline and motor fuel, the tendency in recent years has been decidedly away from the use of petroleum in the crude state as fuel, and to-day only the grades of crude oil averaging in gravity below 20° Baumé are considered as being available for use as fuel, without some form of refining. Outside of California, where some 35 to 40 per cent of the annual output of crude oil is of a gravity below 20° Baumé, the requirements of fuel oil in the United States are satisfied, except locally, by the product of the topping plants and petroleum refineries and by imports of low-gravity crude oil or of topped crude from Mexico.

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RAILROADS.

Reports submitted by railroad companies that operated oil-burning locomotives in the United States show that the quantity of fuel oil consumed by them in 1918 was 36,713,667 barrels, a decrease of 5,524,898 barrels or about 10 per cent of that so consumed in 1917.

Fuel oil consumed by the railroads of the United States, 1909–1918.

Year.	Fuel oil consumed.	Length of line operated by the use of fuel oil.[a]	Total mileage made by oil-burning engines.	Average number of miles per barrel of oil consumed.
	Barrels.	*Miles.*	*Miles.*	*Miles.*
1909	19,905,335	17,676	72,918,118	3.66
1910	23,817,346	22,709	89,107,883	3.74
1911	29,748,845	30,039	109,680,976	3.69
1912	33,605,798	28,451	121,393,228	3.61
1913	33,004,815	29,145	118,672,162	3.60
1914	31,093,266	29,595	118,737,469	3.82
1915	32,830,187	30,776	124,255,525	3.78
1916	38,208,516	31,980	140,434,566	3.68
1917	42,238,565	33,109	148,825,340	3.52
1918	36,713,667	35,211	128,528,039	3.50

[a] Some of these lines also used coal.

The following railroad companies used fuel oil on their lines in 1918:

Arizona:
- Atchison, Topeka & Santa Fe Railway System.
- Southern Pacific Co.

Arkansas:
- Kansas City Southern Railway Co.

California:
- Atchison, Topeka & Santa Fe Railway System.
- Los Angeles & Salt Lake Railroad.
- Northwestern Pacific Railroad Co.
- San Diego & Arizona Railway Co.
- Southern Pacific Co.
- Tonopah & Tidewater Railroad Co.
- Western Pacific Railroad Co.

Florida:
- Florida East Coast Railway Co.

Georgia:
- Central of Georgia Railway Co. (on Tybee district).

Idaho:
- Chicago, Milwaukee & St. Paul Railway Co.
- Great Northern Railway Co.
- Oregon Short Line Railroad Co.
- Oregon-Washington Railroad & Navigation Co.
- Washington, Idaho & Montana Railway Co.

Kansas:
- Atchison, Topeka & Santa Fe Railway System.

Louisiana:
- Atchison, Topeka & Santa Fe Railway System.
- Houston & Shreveport Railroad Co.
- Kansas City Southern Railway Co.
- Louisiana Railway & Navigation Co.
- Louisiana Western Railroad Co.
- Morgan's Louisiana & Texas Railroad & Steamship Co.
- New Orleans, Texas & Mexico Railway.

Missouri:
- Kansas City Southern Railway Co.

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Montana:
Chicago, Burlington & Quincy Railroad Co.
Chicago, Milwaukee & St. Paul Railway Co.
Great Northern Railway Co.
Oregon Short Line Railroad Co.
Nebraska:
Chicago & Northwestern Railway Co.
Nevada:
Atchison, Topeka & Santa Fe Railway System.
Bullfrog Goldfield Railroad Co.
Las Vegas & Tonopah Railroad Co.
Los Angeles & Salt Lake Railroad.
Southern Pacific Co.
Tonopah & Goldfield Railroad Co.
Tonopah & Tidewater Railroad Co.
Western Pacific Railroad Co.
New Mexico:
Atchison, Topeka & Santa Fe Railway System.
El Paso Southwestern System.
Southern Pacific Co.
New York:
Delaware & Hudson Co. (in the Adirondacks).
New York Central Railroad Co. (in the Adirondacks, including Old Forge and the Fulton Chain).
Oklahoma:
Atchison, Topeka & Santa Fe Railway System.
Kansas City Southern Railway Co.
Oregon:
Great Northern Railway Co.
Oregon Trunk Railway.
Oregon-Washington Railroad & Navigation Co.
Southern Pacific Co.
Spokane, Portland & Seattle Railway Co.
South Dakota:
Chicago, Burlington & Quincy Railroad Co.
Chicago & Northwestern Railway Co.
Texas:
Atchison, Topeka & Santa Fe Railway System.
Beaumont, Sour Lake & Western Railway.
Fort Worth & Denver City Railway Co.
Galveston, Harrisburg & San Antonio Railway Co.
Galveston, Houston & Henderson Railroad Co.
Houston, East & West Texas Railway Co.
Houston & Texas Central Railroad Co.
International & Great Northern Railway Co.
Orange & Northwestern Railroad.
St. Louis, Brownsville & Mexico Railway.
San Antonio & Aransas Pass Railway Co.
Texarkana & Fort Smith Railway Co.
Texas & New Orleans Railroad Co.
Texas & Pacific Railway.
Trinity & Brazos Valley Railway Co.
Utah:
Los Angeles & Salt Lake Railroad Co.
Southern Pacific Co.
Washington:
Bellingham & Northern Railway Co.
Chicago, Milwaukee & St. Paul Railway Co.
Great Northern Railway Co.
Northern Pacific Railway Co.
Oregon Trunk Railway.
Oregon-Washington Railroad & Navigation Co.
Spokane, Portland & Seattle Railway Co.
Washington, Idaho & Montana Railway Co.
Wyoming:
Chicago, Burlington & Quincy Railroad Co.
Chicago & Northwestern Railway Co.

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UNITED STATES NAVY.

The greatly increased use of fuel oil by the Navy is shown by the following statistics furnished by the Navy Department:

Consumption of fuel oil by the United States Navy.

	Barrels.
Fiscal year ending June 30, 1919	5,530,932
Fiscal year ending June 30, 1918	4,994,367
Fiscal year ending June 30, 1917	2,079,580

FIELD USE.

The quantity of crude oil consumed during 1917 and 1918 on producing properties, chiefly in the California and Gulf coast fields, as fuel for drilling and pumping is shown in the following table. The statistics, compiled from reports of producing companies, show that 1.4 per cent of the total petroleum output of the United States in 1918 was thus consumed.

Crude petroleum used as field fuel in 1917 and 1918, in barrels.

Field.	1917	1918
Appalachian	.....	6,681
Lima-Indiana	.....	570
Illinois	3,287	4,300
Mid-Continent	462,136	1,086,469
Gulf	1,577,159	1,979,836
Rocky Mountain	16,551	107,590
California	2,798,225	2,505,052
	4,857,358	5,690,486

PRICES.

The average price of fuel oil in 1918 continued the advance of 1917 until about the middle of the year, when the increase was halted by the stabilization program of the Fuel Administration. After the signing of the armistice in November, 1918, there was a distinct drop in the average price of fuel oil.

The following tabulation of monthly prices for semirefined fuel oil at various marketing centers throughout the United States has been compiled mainly from the files of the Oil Trade Journal (New York).

Monthly prices of semirefined fuel oil in 1917 and 1918.

1917.

Month.	Northern Texas.	Northern Louisiana.	Oklahoma.	Southern Texas.	Southern Louisiana.	San Francisco.	Pennsylvania points.	Chicago.	New York.
	Barrels.	Bbls.	Barrels.	Barrels.	Bbls.	Bbls.	Gallons.	Gallons.	Gallons.
January	$1.00	$1.00	$1.00–$2.00	$1.15–$1.20	$1.15	$1.10	$0.04½–$0.05½	.....	.....
February	1.20	1.00	1.00– 2.00	1.25– 1.30	1.30	1.20	.05½– .06½	.....	.....
March	1.20	1.20	1.00– 2.00	1.25– 1.30	1.30	1.20	.05½– .06½	.....	.....
April	1.20	1.20	1.00– 2.00	1.25– 1.30	1.30	1.20	.05½– .06½	.....	.....
May	1.25	1.20	1.00– 2.00	1.25– 1.30	1.30	1.25	.07 – .07½	.....	.....
June	1.30	1.20	1.25– 1.50	1.30	1.30	1.36½	.07	$0.04–$0.05	$0.10–$0.10½
July	$1.50– 1.60	1.25	1.25– 1.50	1.50– 1.60	1.60	1.45	.07	.04– .05	.10½
August	1.50– 1.60	1.40	1.25– 1.50	1.50– 1.60	1.60	1.45	.07 – .08	.04– .05	.10½
September	1.50– 1.60	1.40	1.25– 1.50	1.50– 1.60	1.60	1.45	.08 – .08½	.04– .05	.10½
October	1.50– 1.60	1.50	1.60– 2.00	1.50– 1.60	1.60	1.45	.07½– .08½	.07– .08	.10½– .11
November	1.50– 1.60	1.50	1.25– 2.25	1.50– 1.60	1.60	1.45	.08 – .08½	.07– .08	.11
December	1.65– 1.95	1.50	1.25– 2.25	1.65– 1.95	1.60	1.45	.09½– .09½	.08– .09	.11 – .13

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Monthly prices of semirefined fuel oil in 1917 and 1918—Continued.

1918.

Month.	Northern Texas.	Oklahoma.	Southern Texas.	San Francisco.	Pennsylvania points.	New York.
	Barrels.	*Barrels.*	*Barrels.*	*Barrels.*	*Gallons.*	*Gallons.*
January	$1.65–$1.95	$1.25–$2.25	$1.65–$1.95	$1.45	$0.09½–$0.09½	$0.08½
February	1.65– 1.95	1.25– 2.25	1.65– 1.95	1.45	.09½– .09½	.08½
March	1.65– 1.95	1.25– 2.25	1.65– 1.95	1.45	.09½– .09½	.08½
April	1.85– 2.00	1.75– 2.25	1.85– 2.00	1.45	.09 – .09½	.08½
May	2.00– 2.15	1.75– 2.25	2.00– 2.35	1.60	.09 – .09½	$0.08½– .09
June	2.00– 2.15	1.75– 2.25	2.00– 2.35	1.60	.09 – .09½	.08½– .09
July	2.00– 2.15	1.75– 2.25	2.00– 2.35	1.60	.09 – .09½	.08½– .09
August	1.85– 2.00	1.85– 1.90	2.10– 2.25	1.60	.09 – .09½	.08½– .09
September	1.85– 2.00	1.85– 1.90	2.10– 2.25	1.60	.09 – .09½	.08½– .09
October	1.85– 2.00	1.85– 1.90	2.10– 2.25	1.60	.09½– .10½	.08½– .09
November	1.85	1.85– 1.90	1.75	1.60	.09½– .10½	.08½– .09
December	1.75	1.75– 1.90	1.75	1.60	.08½– .09	.08½– .09

NOTE.—Fuel-oil quotations, especially those covering Pennsylvania points and New York, are nominal. Some spot prices were quoted slightly above the figures given. Such prices are usually small sales, whereas contract prices range under the nominal quotations. In the case of Gulf and Pacific coast fuel oil the business is almost entirely on contract.

WORLD'S PRODUCTION OF PETROLEUM.

World's production of crude petroleum in 1918 and since 1857, by countries.

Country.	Production, 1918.			Total production, 1857–1918.		
	Barrels of 42 gallons.	Metric tons.	Percentage of total.	Barrels of 42 gallons.	Metric tons.	Percentage of total.
United States	355,927,716	47,457,029	69.15	4,608,571,719	614,476,230	61.41
Mexico	63,828,327	9,506,289	12.40	285,182,489	42,584,549	3.80
Russia	40,456,182	5,520,066	7.86	1,873,999,199	247,983,276	24.97
Dutch East Indies [a]	13,284,936	1,836,914	2.58	188,388,513	25,495,114	2.51
Rumania	8,730,235	1,214,219	1.70	151,408,411	21,058,193	2.02
India	[b] 8,000,000	1,066,667	1.55	106,162,365	14,154,982	1.41
Persia	7,200,000	[b] 1,000,000	1.40	14,056,063	1,952,231	.19
Galicia	5,591,620	777,640	1.09	154,051,373	21,424,308	2.05
Peru	[c] 2,536,102	338,147	.49	24,414,387	3,255,251	.33
Japan and Formosa	2,449,069	326,543	.48	38,498,347	5,133,100	.51
Trinidad	2,082,068	289,578	.40	7,432,391	1,033,712	.10
Egypt	2,079,750	277,300	.40	4,848,436	646,458	.07
Argentina	1,321,315	192,612	.26	4,296,093	617,176	.06
Germany	711,260	[b] 100,000	.14	16,664,121	2,254,974	.22
Canada	304,741	40,632	.06	24,425,770	3,256,769	.33
Venezuela	190,080	26,400	.04	317,823	44,142	.02
Italy	35,953	[b] 5,000		973,071	138,588	
Cuba	.....	.....	.....	19,167	2,662	
Other countries	.....	.....	.....	397,000	55,139	
	514,729,354	69,975,036	100.00	7,504,107,138	1,005,516,849	100.00

[a] Includes British Borneo. [b] Estimated. [c] Estimated in part.

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World's production of crude petroleum since 1857,

Year.	Rumania.	United States.	Italy.	Canada.	Russia.	Galicia.	Japan and Formosa.	Germany.
1857	1,977							
1858	3,560							
1859	4,349	2,000						
1860	8,542	500,000	36					
1861	17,279	2,113,609	29					
1862	23,198	3,056,690	29	11,775				
1863	27,943	2,611,209	58	82,814	40,816			
1864	33,013	2,116,109	72	90,000	64,586			
1865	39,017	2,497,700	2,285	110,000	66,542			
1866	42,534	3,597,700	992	175,000	83,052			
1867	50,838	3,347,300	791	190,000	119,917			
1868	55,269	3,646,117	267	200,000	88,327			
1869	58,533	4,215,000	144	220,000	202,308			
1870	83,765	5,260,745	86	250,000	204,618			
1871	99,030	5,205,234	273	269,397	145,129			
1872	91,251	6,293,194	331	308,100	184,201			
1873	104,036	9,893,786	467	365,052	474,379			
1874	103,177	10,926,945	604	168,807	583,751	149,837		
1875	108,569	8,787,514	813	220,000	697,364	158,522	4,566	
1876	111,314	9,132,669	2,891	312,000	1,220,528	164,157	7,708	
1877	108,569	13,350,363	2,934	312,000	1,800,720	169,792	9,560	
1878	109,300	15,396,868	4,329	312,000	2,400,960	175,420	17,884	
1879	110,007	19,914,146	2,891	575,000	2,761,104	214,800	23,457	
1880	114,321	26,286,123	2,035	350,000	3,001,200	229,120	25,497	9,310
1881	121,511	27,661,238	1,237	275,000	3,601,441	286,400	16,751	29,219
1882	136,610	30,349,897	1,316	275,000	4,537,815	330,076	15,549	58,025
1883	139,496	23,449,633	1,618	250,000	6,002,401	365,166	20,473	26,708
1884	210,667	24,218,438	2,855	250,000	10,804,577	408,120	27,923	46,161
1885	193,411	21,858,785	1,941	250,000	13,924,596	465,400	29,237	41,360
1886	168,606	28,064,841	1,575	584,061	18,006,407	305,884	37,916	73,864
1887	181,907	28,283,483	1,496	525,655	18,367,781	343,832	28,645	74,284
1888	218,576	27,612,025	1,251	695,203	23,048,787	466,537	37,436	84,782
1889	297,666	35,163,513	1,273	704,690	24,609,407	515,268	52,811	98,217
1890	333,227	45,823,572	2,998	795,080	28,691,218	650,012	51,420	108,288
1891	488,201	54,292,655	8,305	755,298	34,573,181	630,730	52,917	108,929
1892	593,175	50,514,657	18,321	779,753	35,774,504	646,220	68,901	101,495
1893	535,655	48,431,066	19,069	798,406	40,456,519	692,669	106,384	99,366
1894	507,255	49,344,516	20,552	829,104	36,375,423	949,146	171,744	122,564
1895	575,200	52,892,276	25,843	726,138	46,140,174	1,452,999	141,310	121,277
1896	543,348	60,960,361	18,149	726,822	47,220,633	2,443,080	197,065	145,061
1897	570,886	60,475,516	13,892	709,857	54,399,568	2,226,368	218,559	165,745
1898	776,238	55,364,233	14,489	758,391	61,609,357	2,376,108	265,389	183,437
1899	1,425,777	57,070,850	16,121	808,570	65,954,968	2,313,047	536,079	192,232
1900	1,628,535	63,620,529	12,102	913,498	75,779,417	2,346,505	866,814	258,297
1901	1,678,320	69,389,194	16,150	756,679	85,168,556	3,251,544	1,110,790	313,630
1902	2,059,935	88,766,916	18,963	530,624	80,540,044	4,142,159	1,199,028	353,674
1903	2,763,117	100,461,337	17,876	486,637	75,591,256	5,234,475	1,209,371	445,518
1904	3,509,026	117,080,960	25,476	552,575	78,536,655	5,947,383	1,419,473	637,431
1905	4,420,987	134,717,580	44,027	634,096	54,960,270	5,765,317	1,472,804	560,963
1906	6,378,184	126,493,936	53,577	569,753	58,897,311	5,467,967	1,710,768	578,610
1907	8,118,207	166,095,335	59,875	788,872	61,850,734	8,455,841	2,001,838	756,631
1908	8,252,157	178,527,355	50,966	527,987	62,186,447	12,612,295	2,070,145	1,009,278
1909	9,327,278	183,170,874	42,388	420,755	65,970,350	14,932,799	1,889,563	1,018,837
1910	9,723,806	209,557,248	50,830	315,895	70,336,574	12,673,688	1,930,661	1,032,522
1911	11,107,450	220,449,391	74,709	291,096	66,183,691	10,519,270	1,658,903	1,017,045
1912	12,976,232	222,935,044	53,778	243,336	68,019,208	8,535,174	1,671,405	1,031,050
1913	13,554,768	248,446,230	47,198	228,080	62,834,356	7,818,130	1,942,009	[a] 995,764
1914	12,826,579	265,762,535	39,849	214,805	67,020,522	[a] 5,033,350	2,738,378	[a] 995,764
1915	12,029,913	281,104,104	43,898	215,464	68,548,062	4,158,899	3,118,464	[a] 995,764
1916	8,945,029	300,767,158	50,585	198,123	[c] 72,801,110	6,461,706	2,997,178	[a] 995,764
1917	3,720,760	335,315,601	40,763	213,832	69,960,000	[c] 5,965,447	2,882,378	[a] 995,764
1918	8,730,235	355,927,716	[a] 35,953	304,741	40,456,182	5,591,620	2,449,069	[a] 711,260
	151,408,411	4,608,571,719	973,671	24,425,770	1,873,999,199	154,051,273	38,498,247	16,664,121

[a] Estimated.
[b] Includes British Borneo.
[c] Estimated in part.
[d] Composed of 19,167 barrels produced in Cuba, 127,743 barrels in Venezuela, and 6,856,083 barrels in Persia.
[e] Composed of 190,080 barrels produced in Venezuela and 7,200,000 barrels in Persia.

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by years and countries, in barrels of 42 gallons.

India.	Dutch East Indies.	Peru.	Mexico.	Argentina.	Trinidad.	Egypt.	Other countries.	Total.	Year.
.....	.....	.....	.....	.....	.....	.....	.....	1,977	1857
.....	.....	.....	.....	.....	.....	.....	.....	3,560	1858
.....	.....	.....	.....	.....	.....	.....	.....	6,349	1859
.....	.....	.....	.....	.....	.....	.....	.....	508,578	1860
.....	.....	.....	.....	.....	.....	.....	.....	2,130,917	1861
.....	.....	.....	.....	.....	.....	.....	.....	3,091,692	1862
.....	.....	.....	.....	.....	.....	.....	.....	2,762,940	1863
.....	.....	.....	.....	.....	.....	.....	.....	2,308,780	1864
.....	.....	.....	.....	.....	.....	.....	.....	2,715,524	1865
.....	.....	.....	.....	.....	.....	.....	.....	3,899,278	1866
.....	.....	.....	.....	.....	.....	.....	.....	3,708,846	1867
.....	.....	.....	.....	.....	.....	.....	.....	3,990,180	1868
.....	.....	.....	.....	.....	.....	.....	.....	4,696,985	1869
.....	.....	.....	.....	.....	.....	.....	.....	5,799,214	1870
.....	.....	.....	.....	.....	.....	.....	.....	5,780,063	1871
.....	.....	.....	.....	.....	.....	.....	.....	6,877,267	1872
.....	.....	.....	.....	.....	.....	.....	.....	10,537,720	1873
.....	.....	.....	.....	.....	.....	.....	.....	11,933,121	1874
.....	.....	.....	.....	.....	.....	.....	.....	9,977,348	1875
.....	.....	.....	.....	.....	.....	.....	.....	11,051,267	1876
.....	.....	.....	.....	.....	.....	.....	.....	15,753,923	1877
.....	.....	.....	.....	.....	.....	.....	.....	18,416,761	1878
.....	.....	.....	.....	.....	.....	.....	.....	23,601,405	1879
.....	.....	.....	.....	.....	.....	.....	.....	30,017,606	1880
.....	.....	.....	.....	.....	.....	.....	.....	31,992,797	1881
.....	.....	.....	.....	.....	.....	.....	.....	35,704,268	1882
.....	.....	.....	.....	.....	.....	.....	.....	30,255,479	1883
.....	.....	.....	.....	.....	.....	.....	.....	35,968,741	1884
.....	.....	.....	.....	.....	.....	.....	.....	36,764,730	1885
.....	.....	.....	.....	.....	.....	.....	.....	47,243,154	1886
.....	.....	.....	.....	.....	.....	.....	.....	47,807,083	1887
.....	.....	.....	.....	.....	.....	.....	.....	52,164,597	1888
94,250	.....	.....	.....	.....	.....	.....	.....	61,507,095	1889
118,065	.....	.....	.....	.....	.....	.....	.....	76,632,838	1890
190,131	.....	.....	.....	.....	.....	.....	.....	91,100,347	1891
242,284	.....	.....	.....	.....	.....	.....	.....	88,739,219	1892
298,969	600,000	.....	.....	.....	.....	.....	.....	92,088,127	1893
327,218	688,170	.....	.....	.....	.....	.....	.....	89,335,697	1894
371,536	1,215,757	.....	.....	.....	.....	.....	.....	103,662,510	1895
429,979	1,427,122	47,586	.....	.....	.....	.....	.....	114,159,183	1896
545,704	2,551,649	70,881	.....	.....	.....	.....	.....	121,948,575	1897
542,110	2,964,035	70,905	.....	.....	.....	.....	.....	124,924,682	1898
940,971	1,795,961	89,166	.....	.....	.....	.....	.....	131,143,742	1899
1,078,284	2,253,355	274,800	.....	.....	.....	.....	.....	149,132,116	1900
1,430,716	4,013,710	274,800	10,345	.....	.....	.....	a20,000	167,434,434	1901
1,617,363	2,430,465	286,725	40,200	.....	.....	.....	a26,000	182,006,076	1902
2,510,259	5,770,056	278,092	75,375	.....	.....	.....	a36,000	194,879,669	1903
3,385,468	6,506,485	345,834	125,625	.....	.....	.....	a40,000	218,204,391	1904
4,137,098	7,849,396	447,880	251,250	.....	.....	.....	a30,000	215,292,167	1905
4,015,808	8,180,657	536,204	502,500	.....	.....	.....	a30,000	213,415,360	1906
4,344,162	9,982,597	756,226	1,005,000	101	.....	.....	a30,000	264,245,419	1907
5,047,038	10,283,357	1,011,180	3,932,900	11,472	169	.....	a30,000	285,562,746	1908
6,676,517	11,041,852	1,316,118	2,713,500	18,431	57,143	.....	a20,000	298,616,405	1909
6,137,990	11,030,620	1,330,106	3,634,080	20,753	142,857	.....	a20,000	327,937,629	1910
6,451,203	12,172,949	1,368,274	12,552,798	13,119	285,307	9,150	a20,000	344,174,355	1911
7,116,672	10,845,624	1,751,143	16,558,215	47,007	436,805	205,905	a20,000	352,446,598	1912
7,930,149	11,172,294	2,133,261	25,696,291	130,618	503,616	94,635	a20,000	383,547,399	1913
7,409,792	b11,834,802	1,917,802	26,225,403	275,500	643,533	777,038	a20,000	403,745,652	1914
8,202,674	b12,386,800	2,487,251	32,910,508	516,120	a750,000	262,208	a10,000	427,740,129	1915
8,491,137	b13,174,399	2,550,645	39,817,402	796,920	928,581	411,000	a25,000	459,411,737	1916
8,078,843	b12,928,955	2,533,417	55,202,770	1,144,737	1,602,312	1,008,750	d7,002,973	508,687,302	1917
a8,000,000	b13,284,936	c2,536,102	63,828,327	1,321,315	2,082,068	2,079,750	e7,390,080	514,729,354	1918
106,162,365	188,388,513	24,414,387	285,182,489	4,296,093	7,432,391	4,848,436	14,790,053	7,504,107,138	

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FOREIGN OIL FIELDS.

NORTH AMERICA.

CANADA.

GENERAL STATEMENT.

The following notes on the petroleum industry in Canada are taken from the preliminary report of the Mineral Production of Canada during the calendar year 1918, Mines Branch, Canada Department of Mines, published on February 27, 1919:

The past two years have witnessed slight increases in petroleum production in Ontario due to the development of the new Mosa field in the county of Middlesex, so that the production in 1918 was not only 90,909 barrels, or 42 per cent, in excess of that of 1917, but was the largest production that has been reached since 1910. A bounty of 1½ cents per gallon is paid on the marketed production of crude oil from Canadian oil fields, the administration of the "Petroleum Bounty Act" being under the Department of Trade and Commerce. According to the bounty record the production in 1918 in Ontario was 288,692 barrels (10,104,220 imperial gallons), which at the average price per barrel of $2.70½ was worth $780,912. The New Brunswick production according to bounty payments was 3,009 barrels, worth about $7,402, or an average value of $2.46. For five years there has been a small but growing production of crude petroleum in Alberta, the greater part of which, however, does not earn the bounty because of its lightness or low specific gravity. The approximate production in 1918 was 13,040 barrels, valued at $78,240.

The total production in Canada from all sources was therefore 304,741 barrels (10,665,935 imperial gallons), valued at $866,554, as against 213,832 barrels (7,484,120 imperial gallons), valued at $542,239, in 1917.

The price of crude oil at Petrolia was quoted at $2.48 from August 20, 1917, to February 12, 1918, when the price was increased 10 cents to $2.58. On March 21, the price was again increased by 10 cents to $2.68 and, on July 10, to $2.78, remaining at this price to the end of the year. The average monthly price for the year was thus $2.69½, as against an average of $2.33½ in 1917, $1.98 in 1916, and $1.39½ in 1915.

The production in barrels of the various fields in the Province of Ontario, as kindly furnished by the supervisor of petroleum bounties at Petrolia, was as follows: Petrolia and Enniskillen, 65,467; Oil Springs, 44,671; Moore Township, 6,367; Sarnia Township, 3,438; Plympton Township, 412; Bothwell, 29,116; Tilbury, 25,228; Dutton, 1,875; Onondaga, 1,186; Belle River, 447; Mosa Township, 108,988; Thamesville, 1,566.

In Alberta the production reported was obtained from 5 wells situated in the Turner Valley field, near Black Diamond, about 35 miles southwest of Calgary.

Complete returns of the production of oil refineries have not yet been received, but according to inspection returns of the Inland Revenue Department the total quantity of illuminating oils inspected during the calendar year 1918 was 55,443,056 gallons and the quantity of naphtha or gasoline and other light oils was 74,310,352 gallons.

In 1917 nine oil refineries in Canada used 199,256,799 gallons of crude oil, of which 190,882,740 gallons were imported and 8,434,059 gallons were obtained from Canadian wells. The production of refined oils and petroleum products included gasoline and motor oils, benzoline, benzine, and other light oils, 54,114,786 gallons; illuminating oils, 49,114,564 gallons; lubricating oils, 14,332,549 gallons; gas and fuel oils and tar, 55,643,707 gallons; wax and candles, 13,517,627 pounds, with asphalt and other products. The total value of the products of refineries was $25,137,143.

Exports of petroleum entered as crude mineral oil in 1918 were 270,302 gallons, valued at $28,415, and of refined oil, 1,946,967 gallons, valued at $206,675. There was also an export of naphtha and gasoline of 91,229 gallons, valued at $28,778. The exports in 1917 were: Crude oil, 2,130 gallons, valued at $183; refined oil 28,212 gallons, valued at $6,558; naphtha and gasoline 24,304 gallons, valued at $7,419.

The total value of the imports of petroleum and petroleum products in 1918 was $30,649,580, as against a value of $22,957,688 in 1917 and a value of $14,705,323 in 1916.

The total quantity of petroleum oils, crude and refined, imported in 1918 was 420,728,933 gallons, as compared with 379,148,006 gallons in 1917. A detailed record of the various classes of imports will be found in the accompanying table.

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Imports of petroleum and petroleum products into Canada during the calendar years 1917 and 1918.

	1917		1918	
	Quantity.	Value.	Quantity.	Value.
(a) (1) Crude petroleum, in its natural state .7900 specific gravity or heavier at 60 degrees temperature, when imported by oil refineries to be refined in their own factories	*Gallons.* 183,105,102	$8,411,730	*Gallons.* 148,537,043	$8,255,387
(2) Petroleum (not including crude petroleum imported to be refined, or illuminating or lubricating oils) .8235 specific gravity or heavier at 60 degrees temperature	142,524,473	5,958,930	229,010,561	13,259,646
(b) Crude petroleum, gas oils (other than benzine, naphtha, and gasoline)	854,778	65,404	65,845	7,584
(c) Coal and kerosene, distilled, purified, or refined	13,268,815	978,366	5,241,881	526,606
(d) Illuminating oils, composed wholly or in part of the products of petroleum, coal, shale, or lignite, costing more than 30 cents per gallon	198,281	115,194	205,839	152,825
(e) Lubricating oils, composed wholly or in part of petroleum, costing less than 25 cents per gallon	3,438,430	559,605	2,450,588	476,641
(f) Products of petroleum, n. o. p.	18,521,574	2,708,395	29,246,143	5,595,425
(g) Lubricating oils, n. o. p.	1,877,381	650,325	2,849,051	1,203,130
(h) Gasoline	15,309,172	3,293,760	3,121,982	798,387
	379,148,006	22,741,709	420,728,933	30,375,631
	Pounds.		*Pounds.*	
Paraffin wax	1,620,634	140,722	1,755,422	209,916
Paraffin wax candles	513,337	75,257	327,657	64,033
	.....	22,957,688	.....	30,649,580

Some further information concerning the development of the industry in Canada is taken from the year book of the Oil, Paint, and Drug Reporter.

DEVELOPMENT.

Ontario.—Drilling in Ontario has been pretty well limited to two fields of operation. On the one hand, there has been the rapid and steady development of the new shallow oil field in Mosa Township, Middlesex County. Here a lot of shallow drilling has been done, oil being encountered at between 260 and 465 feet depth. Failures have been comparatively few, since the field was pretty well defined last year; and the initial production of individual wells ranges from 10-barrel pumpers to as high as 200 barrels.

On the other hand, there has been a fairly determined effort to develop a production of oil or gas from the Trenton limestone. The most important deep tests have been those in Dover Township, but Trenton drilling has been scattered over most of the counties of southwestern Ontario. The result so far has been rather unsatisfactory, though the Dover drilling seems to be gradually proving up a small area of deep oil production.

New Brunswick.—Work in the New Brunswick fields has been largely along the line of deepening existing gas wells, with a view to securing additional production from a lower formation. This work has been limited to three or four wells and has been only moderately successful.

Alberta.—The Peace River district has seen considerable drilling in 1918, covering an extensive area, but is not yet a producing field. The production figures given are mere estimates, contingent upon the wells escaping or overcoming water troubles, such as compelled the abandonment of McArthur No. 1 well. The following summary covers the actual operations to the end of 1918:

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Wells drilled in Alberta and elsewhere in Canada in 1918.

Company.	Location.	Status.
ALBERTA—PEACE RIVER DISTRICT:		
McArthur, No. 1	Sec. 31–85–20–5	Finished, abandoned.
McArthur, No. 2	Sec. 24–85–21–5	30 barrels.
McArthur, No. 3	Sec. 4–85–21–5	Drilling at 200 feet.
Victory Oil Co	Opposite Peace River	Drilling at 400 feet.
Northern Pacific	Sec. 11–85–21–5	Drilling at 800 feet.
Slipper Syndicate	High Prairie	Drilling.
Tar Island Co	Sec. 24–85–21–5	50 barrels.
Consolidated Co.	River Lot 9	Drilling at 880 feet.
Community Oils	10 miles downstream	Drilling.
Three Creeks Co.	Sec. 12–85–21–5	Some production.
ALBERTA—MISCELLANEOUS:		
Canadian Western Gas Co.	Barnwell	Gasser, 4,000,000 cubic feet.
Northern Alberta Gas Co.	Viking, No. 9	Gasser, 4,500,000 cubic feet.
BRITISH COLUMBIA:		
Spartan Oil Co	Burnaby district	Drilling at 1,000 feet.
Crows Nest Oil Co	Flathead district	Drilling at 1,580 feet.
Empire Gas Co.	Aldegrove	Shut down.

PRODUCTION.

Petroleum produced in Canada, 1909–1918.

[Reported by Canada Department of Mines.]

Year.	Quantity (barrels).[a]	Value.	Average price per barrel.
1909	420,755	$559,604	$1.330
1910	315,895	388,550	1.230
1911	291,096	357,073	1.227
1912	243,336	345,050	1.418
1913	228,080	406,439	1.782
1914	214,805	343,124	1.598
1915	215,464	300,572	1.392
1916	198,123	392,284	1.979
1917	213,832	542,239	2.536
1918	304,741	866,554	2.844

[a] Barrels of 35 imperial gallons. The Canadian barrel of 35 imperial gallons is the practical equivalent of the United States barrel of 42 gallons, the difference being less than 0.03 per cent.

Petroleum produced in Canada, 1914–1918, by districts, in barrels.

District.	1914	1915	1916	1917	1918
Ontario[a]	212,693	214,444	196,778	202,991	288,692
New Brunswick[a]	1,725	1,020	1,345	2,341	3,009
Alberta	387	.....	.....	8,500	13,040
	214,805	215,464	198,123	213,832	304,741

[a] Reported by supervisor of petroleum bounties at Petrolia, Ontario.

PRICES.

Average monthly prices per barrel for crude oil at Petrolia, Ontario, 1914–1918.

Month.	1914	1915	1916	1917	1918	Month.	1914	1915	1916	1917	1918
January	$1.89	$1.305	$1.846	$2.161	$2.480	August	$1.47	$1.305	$1.927	$2.157	$2.780
February	1.89	1.305	1.969	2.230	2.540	September	1.45	1.440	1.830	2.480	2.780
March	1.89	1.305	2.072	2.230	2.615	October	1.41	1.480	1.933	2.480	2.780
April	1.80	1.305	2.130	2.555	2.680	November	1.36	1.605	1.930	2.480	2.780
May	1.00	1.305	2.130	2.280	2.680	December	1.36	1.700	1.945	2.480	2.780
June	1.58	1.305	2.130	2.280	2.680						
July	1.56	1.305	2.130	2.280	2.751	The year.	1.59	1.395	1.979	2.33½	2.69½

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MEXICO.

GENERAL STATEMENT.

The following quotation is taken from an official report from J. Vásquez Schiaffino, chief of the petroleum bureau of the Department of Industry, Commerce, and Labor in Mexico City, published in the Oil Trade Journal, of May, 1919:

Production by zones.—Mexico's production of crude petroleum in 1918 was 63,828,327 barrels, compared with 55,292,770 barrels in 1917, an increase of 8,535,557 barrels, or 15.43 per cent. Production in 1916 was 39,817,402 barrels.

Of the total 1918 production, 43,970,644 barrels, or the major portion, came from the Tuxpam zone, embracing what are known as the Southern districts in the State of Vera Cruz, and including among others Potrero del Llano, Juan Casiano, Cerro Azul, Los Naranjos, the Tepetate, and the Alamo. This zone produced 34,766,964 barrels in 1917.

The Tampico zone, taking in Panuco and Topila, produced 19,857,361 barrels in 1918, against 20,502,250 barrels in 1917. In the 1917 record is included the Huasteca Petroleum Co.'s Juan Casiano, Cerro Azul, and Chinampa output during the first three months, after which the production of the wells in these districts was carried into the record of the Tuxpam zone.

The Minatitlan zone produced only 321 barrels in 1918, against 23,556 barrels in 1917.

During the first six months of the year, Mexico's crude oil production was 27,933,189 barrels, while during the second half of the year it was 35,895,137 barrels.

Mexican Petroleum and Mexican Eagle.—The Mexican Petroleum Co. (Ltd.), (Pan American Petroleum & Transport Co.) and the Mexican Eagle Oil Co. (Ltd.) maintained their pronounced leadership over the other producing companies during 1918, although the latter showed a slight decrease in production as compared with its 1917 record. The Huasteca Petroleum Co. (Mexican Petroleum Co. (Ltd.), of Delaware) produced 20,186,459 barrels in 1918, compared with 17,325,171 barrels. Its allied company, the Mexican Petroleum Co. of California, produced 1,445,977 barrels, against 1,125,702 barrels. The total for the two in 1918 was 21,632,436 barrels, against 18,450,873 barrels in 1917. These are the Doheny organizations.

The Mexican Eagle Oil Co. (Ltd.) (El Águila), of which Lord Cowdray is the head and in which the Royal Dutch-Shell has purchased a large interest, produced 16,910,646 barrels in 1918, compared with 16,922,323 barrels in 1917.

The record for 1918 shows several new companies with substantial production, among them being the Cía. Mexicana de Petróleo La Libertad (Island Oil & Transport Corporation) and the Cortez Oil Corporation (Port Lobos Petroleum Corporation). The companies producing more than 500,000 barrels, in their proper order, were the Penn Mex Fuel Co., 6,854,081 barrels in 1918, against 4,129,297 in 1917; Freeport & Mexican Fuel Oil Corporation (Sinclair Gulf Corporation), 4,119,654 barrels, against 4,076,982; East Coast Oil Co., 3,457,236 barrels, against 3,143,221; Cortez Oil Corporation, 2,161,757 barrels; Mexican Gulf Oil Co. (Gulf Oil Corporation), 1,728,190 barrels, against 1,160,794; La Libertad, 1,550,869 barrels; Mexican Petroleum Co. of California, 1,445,977 barrels, against 1,125,702; Texas Co., 1,279,747 barrels, against 2,315,433; Cía. Petróleo Tal Vez (Southern Oil & Transport Corporation), 1,152,064 barrels, against 989,561; International Petroleum Co., 609,734 barrels, against 619,828; Tampascas Oil Co., 578,479 barrels, against 174,925; Panuco Boston Oil Co. (Atlantic Refining Co.), 531,511 barrels, against 828,067.

Exports increased in 1918.—Exports of crude petroleum and refinery products from Mexico in 1918 amounted to 7,677,278 metric tons, valued at $140,557,553, Mexican gold, compared with 6,426,036 tons, valued at $53,676,127, in 1917. The increase in value reflects the higher prices that were paid for Mexican oil, especially for the refined and topped oil. The increase of 1,251,242 tons in 1918 over 1917 represents a gain of 19.47 per cent. Crude oil made up 5,057,556 tons of the total and refinery products 2,619,721, the relation between the two classifications being about unchanged as compared with 1917. The 1917 export record was 4,301,744 tons of crude and 2,124,292 tons of refinery products; the 1916 record was 2,978,103 tons of crude and 1,061,623 tons of refinery products, a total of 4,039,726 tons, making the gain for 1917 more than 50 per cent.

Tampico led all ports in 1918 with 2,837,975 tons of crude and 2,433,038 tons of refinery products exported, a total of 5,271,013, and with a combined value of $100,725,081, Mexican gold. In 1917, exports from Tampico were 2,886,892 tons of crude and 1,896,375 tons of refinery products, a total of 4,783,267 tons, having a combined value of $34,889,273. In 1916 exports from Tampico totaled 2,670,274 tons.

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Tuxpam was second, exporting 2,219,581 tons of crude and 36,765 tons of refinery products, a total of 2,256,347 tons, valued at $32,607,810. In 1917 the exports were 1,414,952 tons of crude and 12,266 tons of refinery products, a total of 1,427,118 tons, valued at $12,928,579. In 1916 there were 1,161,643 tons of crude and no refinery products exported.

Puerto Mexico, the southern port through which the Mexican Eagle Oil Co. (Ltd.) makes shipments from its Minatitlan refinery, exported 149,555 tons of refinery products, valued at $7,171,023, as against 207,713 tons, valued at $5,734,453, in 1917, and 220,810 tons of refinery products and 7,000 tons of crude, a total of 227,810 tons, in 1916.

From ports on the west coast of Mexico, Salina Cruz and others, 364 tons of refinery products, valued at $53,631, were exported in 1918, compared with 7,938 tons of refinery products, valued at $122,821, in 1917.

The Huasteca Petroleum Co. led in exports and was closely followed by the Mexican Eagle Oil Co. and the Penn Mex Fuel Co. The Standard Oil Co. of New York was a large shipper of refinery products, principally distillate from the Mexican Petroleum Co.'s Tampico refinery, the total value of its shipments being second to the Mexican Eagle Oil Co.'s, which led in value.

Out of the total of 7,663,639 tons of oil shown as exported to foreign countries, 6,405,731 tons, or about 84 per cent, were shipped to the United States. The slight difference shown in the table of exports from Mexico and the table of exports to the various countries is explained by bunker purchases at the Mexican ports which do not reach foreign destinations.

Record of all completed wells.—A compilation of all borings of which records are available shows a total of 811 wells completed in the Republic of Mexico to the end of 1918. Of this number, 512 were unproductive and 299 were productive. The initial (potential) production of these latter wells is estimated by the department at 253,217.93 cubic meters, or 1,592,740.78 barrels. The actual daily production is 27,801,610 cubic meters, or 174,872 barrels, this representing 10.98 per cent of the potential production. At the end of 1917 the estimated potential daily production of all wells was 212,593.44 cubic meters, or 1,337,212 barrels.

The Mexican Eagle Oil Co. (Ltd.) (El Aguila), is credited with the largest number of wells drilled by any one company—a total of 339, of which 284 were abandoned and 55 were productive, these productive wells having an initial output of 20,590.18 cubic meters, or roughly 129,000 barrels.

The Huasteca Petroleum Co. is credited with 23 completed wells, of which 19 were abandoned and 4 were productive. The potential daily capacity of these four wells is given as 48,553.17 cubic meters, or approximately 300,000 barrels.

The Mexican Gulf Oil Co. (Gulf Oil Corporation), with two productive wells, is credited with a potential daily production of 22,370.5 cubic meters, or approximately 140,000 barrels.

The Texas Co. of Mexico has 10 producing wells with a daily potential capacity of 17,072.19 cubic meters, or approximately 107,000 barrels.

The Penn Mex Fuel Co. has seven productive wells, with a daily initial capacity of 13,969.35 cubic meters, or approximately 88,000 barrels.

The Cía. Petrolera de Tepetate (Gibson, Zahniser & Vincent), the majority stock of which was recently acquired by the Atlantic Gulf & West Indies Steamship Co., is credited with two producing wells having a daily potential capacity of 21,462.86 cubic meters, or approximately 135,000 barrels.

Drilling operations in 1918.—Drilling was done during the year on 75 wells in the principal districts of Mexico, as follows: Panuco, 29; Tuxpam, 22; Ozuluama, 12; Topila, 5; Sarlat, 3; Tamaulipas, 2; San Luis Potosi, 1; Tantoyuca, 1.

Forty-three wells were completed, 15 were abandoned, 28 were producing, and 32 still drilling or shut down.

Panuco led in the number of wells completed, with Tuxpam a close second. Panuco is credited with 13 producing wells with a daily potential production of 10,429.25 cubic meters, or approximately 65,000 barrels, while the seven producing wells credited to Tuxpam had a daily potential production of 44,154.98 cubic meters, or approximately 280,000 barrels. The four producing wells in the Ozuluama district are credited with a daily potential production of 23,565 cubic meters, or approximately 150,000 barrels.

The following information is quoted from the 1918 Year Book of the Oil, Paint, and Drug Reporter, pages 309 and 310:

The last month of the year proved to be unique, inasmuch as it saw more large wells completed than had been the case in any other month, and also, it proved to be the month in which the Mexican Eagle Oil Co.'s famous Potrero del Llano No. 4, one of the world's greatest oil wells, went to salt water. This well, completed

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December 26, 1910, produced over 100,000,000 barrels of petroleum before salt water suddenly invaded it in the first week of last December. The well is producing an emulsion now of, say, half oil and half salt water, at the rate of 50,000 barrels a day, the rate it was producing free oil when the saline invasion occurred. Its developing the saline emulsion affords the first instance of approximately how long one of the capital wells of this region might last, although in considering the nearly eight years of life of this well, it must also be recalled that for the past four years it has practically flowed "wide open," as the oil seeping up outside of the casing precluded any successful attempt to close it in, or even "crack down" the master gate valve on the 8-inch casing.

Drilling at Panuco during the past year was practically confined to what was considered within the limits of proven territory. In this connection the Isleta sector was demonstrated to be quite narrow, while the 8,000-barrel completion in the Camolote sector awakened interest in this western (by south) edge of the pool.

At Topila, another capital well was drilled in the Tamboyoche sector, near the river, where two big wells were drilled in 1917. One other test drilled at the eastern edge of the same sector was a failure.

LAWS AND TAXES.

On February 19, 1918, the Mexican Government issued a decree, the object of which was to nationalize petroleum lands via the taxation route. This decree set forth the following table of taxes, which it declared would be collectable in the future; and at the same time it provided for the manifestation of all oil lands owned in fee simple or leased. The tax table provided—

(*a*) A percentage of cash rents, varying from 10 per cent, where it is less than 5 pesos per hectare (2.47 acres), to 50 per cent on the excess of 10 pesos per hectare.

(*b*) Five pesos per hectare where no cash rent is paid by lessees.

(*c*) A similar tax of 5 pesos per hectare where the fee owner of unleased property seeks to retain the subsoil rights.

(*d*) Fifty per cent of the royalties under leases.

(*e*) Five per cent of the product from fee owners of unleased properties and the payment of the taxes set forth, in consideration of which the Government would issue permits for the exploitation of same, which would be valid in lieu of the titles to the properties or lease agreements with private owners.

To this all of the major companies, with possibly some four exceptions, demurred; and after a series of interviews with the principal officials of the Government, which, from the viewpoint of the interested companies, were bootless, the companies in question brought injunction suits before the Supreme Court (Amparos) of the Republic asking that the Government be restrained from enforcing its decree of February 19, and the subsequent regulatory decrees based thereon.

EXPORT TAXES.

Effective May 1, 1917, the taxes collectable on export oils were ordered based on New York market prices at the rate of 10 per cent of the valuations so derived, the Department of Hacienda readjusting the valuations every two months. The following valuations were in effect for the months of November and December:

Fuel oil having a specific gravity of 0.91	ton..	$13.00
Crude oil having a specific gravity of 0.91	do..	15.00
Crude oil with specific gravity of 0.97	do..	6.00
Gas oil	do..	13.00
Refined gasoline	liter..	.12½
Crude gasoline	do...	.11¼
Kerosene, crude or refined	do...	.04

The figures presented are in Mexican gold. Petroleum or its derivatives sold in the Republic escapes taxation.

PRINCIPAL PRODUCING FIELDS.

The original producing field in the Tampico region was Ebano. Since then, however, new areas have been developed one by one until there are at this time a dozen or more localities where wells have been brought in, some of them of enormous capacity. Among the principal producing fields are Juan Casiano, Cerro Azul, Panuco, Potrero del Llano, Topila, Aguanacida, Alamo, Tepetape, Chinampa. These fields are stretched along the coast for a distance of about 120 miles and extend back toward the interior as far as 50 miles. Most of the oil is of an asphalt base. The fact that

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it does not run high in gasoline content has caused the establishment of several sopping plants for the removal of the gasoline and naphtha, the remainder of the oil being sold for fuel. Refineries are in operation, however, that carry the distilling process to the point that brings forth a large yield of gasoline, leaving a residue of asphalt and other valuable products. During the year 1918 the refining facilities at Tampico were greatly enlarged, and plans are on foot for still further increasing the capacity of the existing plants and the building of new plants during the current year. Much was done during 1918 by the different operating companies in constructing new shipping terminals, installing loading racks, and making general provision for an expansion of their export business. Additional ocean-loading pipe lines were installed in the Gulf outside of the port of Tuxpam; extensive terminals were built at Port Lobos, which seems destined to become one of the principal places of export of the Gulf coast; short lines of railway were built by companies in order to obtain a transportation outlet for the fields where they are operating; and more than 50 miles of modern highway were constructed.

PRODUCTION.

The following statistics are reported by the Petroleum Bureau, Department of Industry, Commerce, and Labor, Mexico City:

Petroleum produced in Mexico, 1901–1918.

	Barrels.		Barrels.
1901	10,345	1910	3,634,080
1902	40,200	1911	12,552,798
1903	75,375	1912	16,558,215
1904	125,625	1913	25,696,291
1905	251,250	1914	26,235,403
1906	502,500	1915	32,910,508
1907	1,005,000	1916	39,817,402
1908	3,932,900	1917	55,292,770
1909	2,713,500	1918	63,828,327

Petroleum produced in Mexico in 1917 and 1918, by zones, in barrels and metric tons.

Zone.	1917		1918	
	Barrels.	Metric tons.	Barrels.	Metric tons.
Tampico	20,502,250	3,162,286	19,857,362	3,050,947
Tuxpam	34,766,964	5,098,626	43,970,644	6,455,310
Minatitlan	23,556	3,354	321	42
	55,292,770	8,264,266	63,828,327	9,506,289

IMPORTS.

Petroleum and petroleum products imported into Mexico from the United States, 1915–1918.

	1915		1916		1917		1918	
	Quantity (gallons).	Value.	Quantity (gallons).	Value.	Quantity (gallons).	Value.	Quantity (gallons).	Value.
Crude	10,132,665	$353,583	7,972,488	$299,914	2,004,464	$81,998	2,192,802	$90,866
Naphtha	119,735	14,011	197,205	24,024	230,059	32,138	420,185	67,721
Gasoline	612,018	87,812	906,565	197,444	986,526	266,258	900,918	276,139
Illuminating	1,772,179	205,569	883,712	108,783	845,220	132,436	1,982,913	271,799
Lubricating	745,739	184,678	619,608	138,757	644,201	189,058	894,576	321,935
Gas oil and fuel oil	542,393	13,998	15,132,541	504,302	21,402,114	768,111	27,552,406	1,038,321
Residuum	5,667	331	41,952	2,563	12,732	1,047	85,725	3,665
	13,930,396	859,982	25,754,071	1,275,787	26,125,316	1,471,046	34,029,525	2,070,446

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Mineral oils imported into Mexico from the United States, 1909–1918.

	Crude.		Refined, including residuum.		Total.	
	Quantity (gallons).	Value.	Quantity (gallons).	Value.	Quantity (gallons).	Value.
1909	35,507,689	$1,219,656	2,310,996	$338,999	37,818,685	$1,558,655
1910	33,117,008	1,163,977	1,779,376	330,458	34,896,384	1,494,435
1911	22,611,875	839,489	3,134,850	338,049	25,746,725	1,177,538
1912	19,135,187	740,583	2,211,470	298,064	21,346,657	1,038,647
1913	15,047,098	552,289	1,865,384	330,485	16,912,482	882,774
1914	9,207,354	326,124	3,955,738	447,571	13,163,092	773,695
1915	10,132,665	353,583	3,797,731	506,399	13,930,396	859,982
1916	7,972,488	299,914	17,781,583	975,873	25,754,071	1,275,787
1917	2,004,464	81,998	24,120,852	1,389,048	26,125,316	1,471,046
1918	2,192,802	90,866	31,836,723	1,979,560	34,029,525	2,070,446

WEST INDIES.

TRINIDAD.

The Trinidad petroleum industry, according to a report issued by the inspector of mines, continued to expand during 1918. The total production of crude petroleum in 1918 was approximately 72,872,398 gallons, as compared with 56,080,914 gallons in 1917. During the war, development operations were carried on with difficulty, and some of the smaller companies suspended operations altogether. It is expected, however, that in 1919 several of these companies will resume activities. The prospects are regarded as very favorable, as some important British interests have recently acquired oil rights over large tracts of land.

The number of new wells drilled in 1918 was 41 (37 on Crown and 4 on private lands), and in 29 of these, oil was found. The number of wells drilled in Trinidad up to the 31st of December, 1918, amounted to 410, of which 236 are on Crown lands. There were 12 producing companies in 1918, as against 11 at the end of 1917.

Exports of crude and refined oil in 1918 amounted to 45,689,234 gallons, as compared with 37,777,919 gallons in 1917.

Petroleum produced in Trinidad, 1908–1918.

	Barrels.		Barrels.
1908	169	1914	643,533
1909	57,143	1915	750,000
1910	142,857	1916	928,581
1911	285,307	1917	1,602,312
1912	436,805	1918	2,082,068
1913	503,616		

CUBA.

Reports on drilling for oil in Cuba for the year 1918 are of a generally unfavorable nature, and lack of material prevented drilling in many places.

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DOMINICAN REPUBLIC.

The following discussion of oil possibilities in the Dominican Republic is quoted from the Oil Trade Journal of March, 1919:

A considerable area in the southern part of the island of Haiti, included in the Dominican Republic, has proved to be geologically favorable for the location of productive pools. In one area seepages of oil have been observed for many years accompanied by discharges of inflammable gas that have been the cause of much wonderment to the natives. The only known drilling operations carried on within the Republic, however, were undertaken near Azua in 1904–1906. On account of the low price of crude in the United States at that time, as well as the apparently extensive supplies in the Texas and Louisiana coast districts, with which the Azua field would have entered into competition, capital could not be enlisted to continue the operations.

The oil obtained in the Azua field was of distinctive type, low in gasoline, but with a fairly high percentage of kerosene and the heavier distillates and having a residue of unusual value as a lubricant or low cold test fuel oil, due to the lack of paraffin.

Recent tests of this crude, obtained from a well less than 1,000 feet in depth near Azua, give the following distillation analysis: Specific gravity at 60° F., 0.9390; gravity Baumé, 20.4°; weight per gallon, in pounds, 7.752; amount of sulphur, 3.07 per cent; British thermal units per pound, 18,460; British thermal units per gallon, 143,110; open-cup flash, 185° F.; open-cup fire, 220° F. The initial boiling point was 160° C., and 56 per cent residue remained at 300° C.

When the first test work was done, in 1904, one of the wells made repeated flows of oil over the derrick and was variously estimated as having a capacity of from 500 to 2,500 barrels. Later a flow of water was encountered that could not be handled effectively, and this dampened the ardor of the company conducting the operations.

Recently the Azua district has been the scene of careful geological investigation, and predictions have been made that during 1919 this area will receive a careful test by experienced operators equipped with modern machinery.

CENTRAL AMERICA.

A detailed geologic examination of a large part of Costa Rica and Panama was completed by a subsidiary of the Sinclair Gulf Corporation in 1918 and drilling was begun on Columbus Island near Bocas del Toro, Panama, which is on the Atlantic coast not far from the Costa Rica boundary. Two tests are reported to have been started in Costa Rica, near Limon. Late in the year it was reported that a British corporation had obtained a concession to exploit oil in the north half of Costa Rica.

Concessions covering oil development are reported to have been granted in Guatemala and Honduras, but no active work has been undertaken in these countries.

SOUTH AMERICA.

COLOMBIA.

The following discussions of oil possibilities and development in Colombia are quoted from the Oil Trade Journal of February, 1919, pages 36 and 37, and March, 1919, pages 72–74:

The legal and legislative phases of developing oil properties in Colombia, South America, received much attention during 1918 both from the Government and the companies operating or contemplating investment in that country. Most of the Latin-American countries have as their basic land laws the codes established under the old Spanish régime. In some cases these have been revised by legislative enactment and by executive decree, but some of the republics, as in the case of Mexico, have been inclined to hark back to the Spanish law, which vested in the Government full ownership of subsoil rights.

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A measure relative to Government ownership of subsoil rights and, specifically, ownership of petroleum in lands acquired from the Government since 1874, was presented to the last Colombian Congress, which closed its sessions in November, 1918. This act met with spirited opposition. When it became apparent that the bill could not pass in its existing form, the Government appointed a committee, which modified the provisions so that they would apply only to the future and exclusively to Government lands or to land concessions granted by the Government. In other words, the retroactive feature was eliminated. This was satisfactory to all interests, but the congress adjourned without final action having been taken on the bill.

Geological and surface indications of oil are prominent in Colombia. While the Standard Oil Co. of New York spent over $1,000,000 in prospecting districts near the Atlantic coast and gave up this enterprise as unsatisfactory, the work already accomplished at interior points has been successful in certain instances and is promising for the future.

The Tropical Oil Co. (Mares concession) on the bank of the Magdalena River, some 400 miles from the river's mouth, has drilled in several wells rated as good producers. The headquarters of the company is at Barranca Bermeja. This company's plans include the construction of a refinery and the building up of a large domestic trade. An immediate market for fuel oil is seen in the thirty-odd river steamers which ply between Barranquilla and La Dorado, a distance of 600 miles. These vessels now burn wood and are subject to great delay and slow speed.

Less than half of the great area of Colombia is explored. That part of the country lying east of the inside range of the Andes to the Amazon is largely a tropical wilderness, from which explorers and hunters bring reports of oil seepages. Dr. Hamilton Rice, of Newport, R. I., explorer and scientist, is an authority on the country sloping down to the Amazon. He has led two expeditions for exploration of that region, each of which consumed 14 months.

At the foot of the eastern range of the Andes, in the Amazon country, there are known oil seepages. Four days' mule-back from Bogota covers the distance and the oil has frequently been used by travelers in bathing sores on cattle and pack horses.

Location of the Barco concession.—The Barco concession, which was originally taken over by the Carib Syndicate (Ltd.), of New York, and ownership of which is now vested in that company and the Colombian Petroleum Co. (H. L. Doherty & Co.), is situated in Colombia at the Venezuelan border where the Catatumba and Zulia rivers pass from Colombia into Venezuela, emptying into Lake Maracaibo.

The operators of the concessions on the Venezuelan-Colombian border are continually meeting with difficulties in bringing up supplies and machinery through Venezuela. This is the logical routing, but, in the case of a concession on the Colombian side, a factor at present is the frontier dispute existing between Colombia and Venezuela. This controversy has been in evidence for nearly a century, and in spite of agreements, treaties, and all efforts of the Colombian Government there is constant friction between the two countries, with the result that the operators of the Colombian concessions on the border have found it difficult to get the Venezuelan Government's consent to transport machinery by way of Lake Maracaibo. To reach the Barco concession from the Magdalena, a mountain range must be crossed, making the transportation of machinery over that route quite difficult.

In Colombia the American companies have been laying plans for extensive development, the most active being the Tropical Oil Co., at Pittsburgh, the Carib Syndicate (Ltd.), and the operating company of the Barco concession known as the Colombian Petroleum Co. (H. L. Doherty & Co. and Carib Syndicate Ltd). During the past year actual drilling operations were confined to the locations of the Tropical Oil Co., near Barranca Bermeja, and the Carib Syndicate, near Hond, both locations being in Magdalena River valley.

The credit of having completed the first Colombian petroleum gushers goes to the Tropical Oil Co. The Tropical's four wells, now drilled or drilling, are about 15 miles up Colorado River, a tributary of the Magdalena. The company started exploration work two and a half years ago, and began drilling No. 1 well early in 1917, but was hampered by lack of materials, so that No. 2 well, situated 2 miles from No. 1, was the first to be completed, coming in early in 1918 at 1,525 feet and flowing from, 1,500 to 8,000 barrels a day through three strings of pipe. It was successfully shut in. No. 1 well was completed late in 1918. It was drilled to 2,270 feet, and came in as a gusher, shooting oil over the derrick and flowing four and a half hours before being shut in. This well is variously rated from 2,000 to as high as 20,000 barrels. No. 3 well, located about a mile from No. 1 on a diagonal line, struck oil at 900 feet, but caught fire, and the derrick was destroyed. No. 4 is now drilling. The oil is dark in color and has some asphalt in its composition, but gives a good yield of gasoline.

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The Tropical Co. has under consideration the building of a pipe line from its concession to Cartagena, as well as the construction of a refinery in Colombia capable of handling its oil. Tests of the oil from well No. 1, which is a light-grade crude of 36° Baumé, showed an approximate yield of 30 per cent of gasoline 58° and above, 32 per cent gravity amber oil per day, sufficient to operate a small local refinery on the property.

An analysis of this seepage oil shows gasoline, 24.4 per cent; kerosene, 18.4 per cent; fuel oil, 22.1 per cent; light machine oil, 6.4 per cent; lubricating oil, 12.4 per cent; cylinder stock 15.2 per cent; loss, 1.1 per cent.

VENEZUELA.

The following is quoted from the Oil Trade Journal of April, 1919, page 72, and March, 1919, pages 74–76:

CARIBBEAN PETROLEUM'S OPERATIONS IN VENEZUELA.

With a view to developing the local oil industry in Venezuela and supplying the adjacent and foreign markets with petroleum products, the Caribbean Petroleum Co., a subsidiary of the General Asphalt Co., in which the Royal Dutch-Shell group is also interested, for several years past has carried on quite extensive operations in that country. This work has been conducted in both eastern and western Venezuela, but principally in the western section of the country, extending roughly around the whole perimeter of Lake Maracaibo.

Systematic geological surveys of the western section of Venezuela, along the eastern shore of Lake Maracaibo and 50 miles to the westward of the lake, were made under the supervision of Dr. Ralph Arnold. Oil-bearing areas were found mostly in the wild and undeveloped portions of the country, which hampered the preliminary investigation work and called for the utmost zeal and patience in combating the ever-present natural obstructions of the tropical jungle. In January, 1914, the first test well was drilled to shallow depth, passing through several beds of rich sands showing oil of good quality. Encouraged by this result, several deeper wells were later sunk until a satisfactory production of oil has been obtained.

To facilitate the handling of petroleum, storage tanks and a pumping station have been erected, as well as a pipe line connecting the Mene Grande field with the shipping point at San Lorenzo, on the eastern shore of Lake Maracaibo, a distance of about 11 miles. Despite the exigencies of war and the resultant shortage of labor, a modern refinery also has been erected at San Lorenzo, equipped with the latest appliances. In addition to the refinery, a factory has been built for the manufacture of containers. These plants are meeting the local needs of Venezuela, and an experienced sales department has been organized and is marketing petroleum products throughout that country.

A wharf with an extension pipe line and pumping station is part of the equipment at this point, and was erected to facilitate the export trade. By this arrangement the company is able to deliver aboard steamships and lighters a substantial quantity of oil per hour.

One of the most important undertakings of the company is the erection of a large refinery on the Island of Curaçao, lying off the north coast of Venezuela. This plant is constructed on the Trumble system and embodies the latest refining methods. During the war the work was seriously hampered by difficulties experienced in obtaining materials, due to the lack of transportation facilities, but the plant is now practically completed. The first large cargo of Venezuelan petroleum was delivered from Curaçao in January, 1918.

Upon the acquisition of high-powered tugs and the delivery of two more large barges, now nearly ready, transportation between Venezuela and Curaçao will be much increased, the latter point becoming the shipping point for foreign markets. Every provision is being made to handle miscellaneous petroleum products and bunker oil for vessels using the Panama Canal. Distributing stations have also been erected at La Guayra, Puerto Cabello, and Maracaibo, in Venezuela.

Along the coast of Venezuela, and extending several hundred miles to the west, are found important seepages of asphaltic oil. These indications have been carefully checked by geologists employed by operating interests in Venezuela, generally known as the Royal Dutch-Caribbean Petroleum group. A number of concessions have been granted by the Venezuelan Government for the exploitation of these areas, and were it not for the rather unsettled political conditions in Venezuela, development and testing work would be much further advanced.

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The Caribbean Petroleum Co., which is owned jointly by the General Asphalt Co., of Philadelphia, and the Royal Dutch interests, is by far the most active developer of Venezuelan oil. Two prolific areas have been discovered by this company on opposite shores of Lake Maracaibo; a refinery sufficient to deal with the needs of Venezuela, with a modern plant for packing oil in tins, has been completed at San Lorenzo, on the eastern side of the lake; and a line of barges to transport crude oil to the Royal Dutch refinery on the near-by Island of Curaçao has commenced deliveries of Venezuelan oil on a substantial scale. The Caribbean petroleum organization has already spent several millions of dollars in preparing for a development of South American business.

The refinery at Curaçao is modern, and is located at the end of a deep bay that will accommodate tankers of large size. Its capacity is estimated at 10,000 barrels daily. The location of this expensive plant on an isolated island which has small chance of becoming of itself a producer of crude was probably due to the lack of suitable harbors near the Venezuelan production, reinforced by the consideration that until political conditions are more stable in Venezuela the plant would be safer on Dutch soil.

The entrance to the Venezuela fields of the Maracaibo basin is through an extensive stretch of shallow water known as the Venezuelan Gulf, and then through a channel with a minimum depth of 12 feet into the fresh-water lake of Maracaibo. Permanently to deepen this channel would be extremely difficult, and this has made barging of the crude necessary. It is expected, however, that a more satisfactory loading berth will eventually be provided on the west shore of the Venezuelan Gulf, to which a pipe line can be laid from the producing areas. The crude thus far produced is of very dark color and of varying gravity and generally of asphaltic base near the coast. * * *

At least two of the three wells of the Colon Development Co. are said to be of large capacity from depths of less than 1,300 feet. The producing formation is sandstone, and the wells are of the gusher type. One of them, on the Rio del Oro, is reported to have flowed between 1,500 and 2,000 barrels in 24 hours through 8-inch pipe with the drill in the top of the formation. The oil is about 36° Baumé, with a good yield of gasoline and kerosene, and has a paraffin base.

Another small development near San Cristobal has yielded for a number of years a small quantity of crude that is used locally.

Petroleum produced in Venezuela in 1917 and 1918.

Year.	Quantity.		Value.
	Barrels.	*Metric tons.*	
1917	127,743	17,742	$145,984
1918	190,080	26,400	211,200

GUIANA.

According to a report by Consul George E. Chamberlin dated June 18, 1918, the following article appeared in the Daily Argosy of Georgetown, under that date:

It is understood that the Venezuelan Oil Concessions (Ltd.), an English company operating in Venezuela, of which Viscount Cowdray, president of S. Pearson & Sons, in many parts of the world, is the head, has secured from the Colonial Office a large concession in the North West District to explore for oil. The area aggregates something like 2,000 square miles.

At present the company has a large staff of mineralogists, surveyors, and geologists prospecting for oil in Venezuela. It is understood that before the end of the year the party is likely to visit this colony with the necessary equipment to carry on exploration work.

ECUADOR.

According to a recent report from United States Consul General Frederick W. Bolden, of Ecuador, petroleum is now used for fuel at a brewery and electric-light plant, at which about 25,000 barrels are burned each year. At Guayaquil and Quito railway officials have also decided to change the locomotives from coal burners to oil burners.

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Exploration of the petroleum of Ecuador has been carried on for some years by the geologists of the Lobitos Oil Fields Co. (Ltd.), which has acquired a large area of promising territory lying along the seashore. It is reported that in this property, besides surface indications, one well has been sunk which reached the oil sand at a little more than 2,000 feet and furnished a moderate production.

PERU.

The production of petroleum in Peru in 1918 was 2,536,102 barrels, a very slight increase as compared with the production in 1917. Increase in production is reported from Negritos and Zorritos fields, and a slight decrease from the Lobitos fields. The development during the year followed along lines already standardized by the companies which have been operating there for some years past and no new work of special significance was undertaken.

Petroleum produced in Peru, 1909–1918, in barrels of 42 gallons each.

Year.	Lobitos.	Negritos.	Zorritos.	Lake Titicaca (Huancane).	Lagunitos.	Total.	
						Barrels.	Metric tons.[a]
1908	319,898	[b] 543,750	71,429	[c] 76,103	.....	1,011,180	134,924
1909	429,195	[b] 740,070	70,750	[c] 76,103	.....	1,316,118	175,482
1910	400,080	[b] 773,025	107,000	[c] 50,000	.....	1,330,105	177,347
1911	391,290	[b] 882,698	64,286	[c] 30,000	.....	1,368,274	182,436
1912	587,048	1,071,000	78,095	[c] 15,000	.....	1,751,143	233,486
1913	557,355	1,136,490	83,343	[c] 10,000	346,073	2,133,261	284,434
1914	504,743	1,032,210	88,136	[c] 10,000	282,713	1,917,802	255,707
1915	664,972	1,355,925	72,736	[c] 1,000	392,618	2,487,251	331,633
1916	654,060	[b] 1,822,733	73,852	.....	[d]	2,550,645	340,086
1917	686,595	[b] 1,771,560	75,262	.....	[d]	2,533,417	337,789
1918	639,098	[b] 1,820,814	76,190	.....	[d]	2,536,102	338,147

[a] One metric ton=7.5 barrels.
[b] Includes Lagunitos.
[c] Estimated.
[d] Included in Negritos.

Petroleum produced, shipped, and in stock and number of producing wells in Lobitos oil field, Peru, 1909–1918.

Year.	Production.		Shipments.	Stock Dec. 31.	Producing wells Jan. 1.
	Metric tons.	Barrels.	Metric tons.	Metric tons.	
1909	57,226	429,195	54,289	11,797	62
1910	53,344	400,080	.....	.....	.....
1911	52,172	391,290	.....	.....	92
1912	78,273	587,048	.....	.....	105
1913	74,314	557,355	.....	.....	110
1914	67,299	504,743	.....	.....	.....
1915	88,613	664,972	.....	.....	119
1916	88,208	654,060	.....	.....	131
1917	96,546	686,595	.....	.....	143
1918	85,213	639,098	.....	.....	.....

Petroleum produced in Negritos oil field, Peru, 1909–1918.

Year.	Metric tons.	Barrels.	Year.	Metric tons.	Barrels.
1909	98,676	740,070	1914	137,628	1,032,210
1910	103,070	773,025	1915	180,790	1,355,925
1911	117,693	882,698	1916[a]	243,031	1,822,733
1912	142,800	1,071,000	1917[a]	236,208	1,771,560
1913	151,532	1,136,490	1918[a]	242,775	1,820,814

[a] Includes Lagunitos field.

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Petroleum produced in Zorritos oil field, Peru, 1909–1918, in gallons.

Year.	Crude.	Refined.[a]	Gasoline.	Benzine.	Year.	Crude.	Refined.[a]	Gasoline.	Benzine
1909	2,971,510	469,610	96,520	.....	1914	3,701,718	482,850	277,440	.....
1910	4,494,000	.....	.....	.....	1915	3,054,900	461,510	362,230	.....
1911	2,700,000	650,000	.....	200,000	1916	3,101,790	468,790	396,720	.....
1912	3,280,000	476,620	226,440	.....	1917	3,161,017	377,645	461,206	.....
1913	3,500,424	565,320	324,000	.....	1918[b]	3,200,000	.....	.....	.....

[a] Kerosene. [b] Estimated.

ARGENTINA.

The output of petroleum in Argentina in 1918 was 1,321,315 barrels, an increase of 176,578 barrels, or 15 per cent, as compared with the output in 1917. According to an article in the Review of the River Plate of May 23, 1919, the increase would have been considerably more had it not been for the stoppage of work by reason of a strike. Twenty-five new wells were completed and three were deepened, a relatively small record owing to the difficulty of obtaining drilling materials and piping. Manufacture of piping in Argentina has been attempted but without satisfactory results. A plan of work has been formulated to increase the output and for the erection of a refinery, purchase of tank steamers, and acquisition of new machinery of a general nature, and for increased development in all phases of the work.

Government oil fields were operated by the Dirección general de la explotación del petróleo de Comodoro Rivadavia, Department of Agriculture, Argentina. In addition to the Government-operated fields, two private companies produced small quantities of petroleum during 1918—the Compañía argentina de Comodoro Rivadavia and the Astra Co.

Petroleum produced in Argentina, 1909–1918.

Year.	Metric tons.	United States barrels.	Year.	Metric tons.	United States barrels.
1909	2,700	18,431	1914	40,530	275,500
1910	3,050	20,753	1915	75,900	516,120
1911	1,920	13,119	1916	116,000	796,920
1912	6,850	47,007	1917	166,871	1,144,737
1913	19,050	130,618	1918	192,612	1,321,315

EURASIA.

RUSSIA.

Information concerning petroleum operations in Russia during 1918 is very meager. The following is an estimate of the production of the Baku fields published by the Petroleum Times on March 8, 1919:

1918.	Poods.	1918.	Poods.
January	28,573,739	August	11,207,224
February	22,745,368	September	5,666,816
March	20,000,000	October	9,529,413
April	17,700,000	November	11,683,727
May (18 days)	10,918,041	December	12,377,067
June	17,564,684		
July	17,225,915		185,191,994

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These figures do not include the wells dug by hand. As the production of these is estimated at about 1,000,000 poods a month, the total of the whole of the Apsheron Peninsula may be taken at 200,000,000 poods for the year 1918.

On February 22, 1919, the Petroleum Times published the following article concerning the Maikop fields:

We understand that a telegram dated Apscheronskaia, January 15, 1919, has been received by the Anglo-Maikop Corporation from their chief engineer in Russia, stating that the general and financial position of the companies under its control is good, that the oil properties are practically intact, and that production has been carried on throughout the year.

The production of the principal allied companies for the year 1918 has been as follows: Maikop Combine, 1,980,000 poods; Black Sea Amalgamated Oilfields, 980,000 poods. The present normal daily production of the Maikop Combine is 7,000 poods and of the Black Sea Amalgamated Oilfields 3,000 poods.

The recently completed new well No. 6 of the Maikop Combine is giving a daily production of 1,300 poods. In the new well No. 4 of the Black Sea Amalgamated the water has been successfully shut off; well No. 5 is in drilling depth 925 feet; and work on well No. 6 is expected to start soon.

Maikop Pipe Line & Transport Co. continued pumping regularly throughout the year.

The price of crude oil at Ekaterinodar has been increased since September to 7 roubles a pood and pumping charges to 52 kopecks a pood.

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Petroleum produced in Russia, 1909–1918.

Year.	Baku.		Grosny.		Maikop.		Emba.		Other.		Total.	
	Poods.[a]	Barrels of 42 gallons.	Poods.	Barrels of 42 gallons.	Poods.	Barrels of 42 gallons.	Poods.	Barrels of 42 gallons.	Poods.	Barrels of 42 gallons.	Poods.	Barrels of 42 gallons.
1909	492,500,000	59,123,650	57,033,015	6,846,700	.....	.....	.....	.....	.....	.....	549,533,015	65,970,350
1910	508,456,121	61,039,149	74,048,358	8,889,359	1,304,800	156,640	.....	.....	[d] 2,094,381	251,426	585,903,660	70,336,574
1911	454,206,853	54,526,633	75,189,591	9,026,361	7,933,936	952,453	.....	.....	[e] 13,979,771	1,678,244	551,310,151	66,183,691
1912	473,200,000	56,806,723	65,400,000	7,851,140	9,200,000	1,104,442	.....	.....	[f] 18,800,000	2,256,903	566,600,000	68,019,208
1913	404,538,000	48,563,985	73,659,265	8,842,649	4,802,926	576,582	7,182,000	862,184	[g] 33,228,000	3,988,956	523,410,191	62,834,356
1914	412,246,851	49,489,418	98,445,187	11,818,150	3,956,906	475,019	16,675,000	2,001,801	26,957,000	3,236,134	558,280,944	67,020,522
1915	421,139,305	51,757,419	88,159,052	10,583,320	7,582,000	910,204	16,632,000	1,996,639	27,493,000	3,300,480	571,005,357	68,548,062
1916 [b]	464,902,000	55,810,564	102,731,246	12,332,683	2,000,000	240,096	15,200,000	1,824,730	21,600,000	2,593,037	606,433,246	72,801,110
1917 [c]	413,000,000	49,560,000	123,000,000	14,760,000	8,000,000	960,000	15,000,000	1,800,000	24,000,000	2,880,000	583,000,000	69,960,000
1918 [c]	200,000,000	24,009,604	110,000,000	13,205,282	3,000,000	360,144	14,000,000	1,680,672	10,000,000	1,200,480	337,000,000	40,456,182

[a] 61.05 poods=1 metric ton crude; 8.33 poods crude=1 United States barrel of 42 gallons; 8 poods illuminating oil=1 United States barrel of 42 gallons; 8.18 poods lubricating oil=1 United States barrel of 42 gallons; 9 poods residuum=1 United States barrel of 42 gallons; 7.50 poods naphtha=1 United States barrel of 42 gallons; 8.3775 poods other products=1 United States barrel of 42 gallons, estimated; 1 pood=36.112 pounds; 1 kopeck=0.515 cents.

[b] Estimated in part.

[c] Estimated.

[d] Includes as follows: Sviatoi, 1,392,306 poods; Ferghana, 610,500 poods; and Taman, 91,575 poods.

[e] Includes as follows: Sviatoi, 2,515,363 poods; Tcheleken, 10,205,740 poods; and Ferghana, 610,500 poods; other districts, 648,158 poods.

[f] Includes as follows: Sviatoi, 3,300,000 poods; Tcheleken, 13,300,000 poods; and Ferghana, 2,200,000 poods.

[g] Includes as follows: Sviatoi, 4,733,000 poods; Balakhani, 13,860,000 poods; Berekei, 6,000,000 poods; Ferghana, 1,406,000 poods; and Tcheleken, 7,229,000 poods.

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GALICIA.

The United States Geological Survey has no reliable information concerning the production of Galicia during 1918. The figures for 1918 in the table are obtained by comparison of various statements and form what is believed to be the most reliable estimate that can be made at the present time.

Petroleum produced in Galicia, 1914–1918, in metric tons.[a]

Field.	1914	1915	1916	1917	1918
East Galicia:					
Tustanowice	[b] 356,447		483,840	403,212	321,750
Boryslaw	[b] 116,613		254,095	247,926	297,400
Schodnica					
Urycz					
Mraznica			32,172	51,929	58,490
Other fields				6,562	
West Galicia:					
Potok		578,388			
Rogi					
Rowne					
Krosno			128,563	[c] 120,000	[c] 100,000
Tarnawa-Wielopole-Zagorz					
Kobylanka, Kyrg, Zalawie, Lipinki, Libusza, etc					
	[c] 700,000	578,388	898,670	829,629	777,640

[a] 1 metric ton = 7.1905 barrels of crude petroleum of 42 gallons = 2,204.62 pounds.
[b] Figures for first six months only.
[c] Estimated.

Petroleum produced in Galicia, 1909–1918.

Year.	Metric centners.[a]	Barrels of 42 gallons.	Year.	Metric centners.[a]	Barrels of 42 gallons.
1909	20,767,400	14,932,799	1914	[b] 7,000,000	5,033,350
1910	17,625,600	12,673,688	1915	5,783,880	4,158,999
1911	14,629,400	10,519,270	1916	8,986,700	6,461,705
1912	11,870,070	8,535,174	1917	8,296,290	5,965,447
1913	10,872,860	7,818,130	1918	7,776,400	5,591,620

[a] 1 metric centner or quintal = 100 kilograms (220.462 pounds); 1 metric centner or quintal of crude petroleum = 0.71905 barrel of 42 gallons.
[b] Estimated.

RUMANIA.[1]

At the end of November, 1916, the Rumanian armies were forced to abandon Walachia to the invading enemy. Accordingly, the Government of that country agreed with its allies that destruction of the petroleum equipment was necessary in the superior interest of the national defense in order that the enemy might not continue the production and refining of oil and thus control a powerful force against Rumania itself and its allies. Measures were therefore taken by an Anglo-Rumanian commission to plug all the productive wells, to burn the oil reservoirs and their contents, and to completely destroy the refineries.

On taking possession of our oil fields the enemy saved a part of the equipment that was then in flames, but most of the refineries and wells were either totally destroyed or so badly damaged that they could not be operated without restoration or extensive repairs. Only such equipment as could not be burned without hindering or imperiling the safe retreat of the Rumanian armies was left intact.

A complete reorganization of the petroleum industry was begun as soon as the armies of the enemy occupied the oil fields, and in February, 1917, the first well was reopened in Campina, and others soon followed in the same and other districts. Because of the

[1] The Rumanian petroleum industry during the last three years and its present state: Moniteur du pétrole roumain, vol. 18, pp. 3, 6–7, July 15, 1919.

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wealth of technical information available and of the personnel of enemy specialists who knew the conditions of the industry in our country, a small production was obtained within a relatively short time, but the difficulties of obtaining production of any importance were very great.

Within a short time the two largest refineries of the country, the Steaua Romana of Campina and the Vega of Ploesti were put in working order, and the refining industry was restored to some extent sooner than one would have believed possible. * * *

Granting the Rumanian petroleum industry the importance which the German staff accorded it, as the only source of that product indispensable to the continuation of its submarine warfare as well as for fuel for its other enterprises and for its entire park of aviation and automobiles, it is easily understood what activity the German military administration developed. A special body was created for handling this matter, called "Kommando der Erdölfelder in Rumänien" (Command of petroleum exploitation in Rumania)—abridged to "Kodöl"—and also a special section called "Mineralöl-Abtheilung" of the military adminstration of Rumania.

The first body, with headquarters at Campina, occupied itself with all questions regarding operation and development, the regulation of the industry, and the furnishing of working material; the second body, with headquarters at Bucharest, had charge of the refining of crude petroleum, its apportionment by destination, and the transportation of its products into Germany or the other countries allied with her.

All companies and enterprises were requested to begin at once to restore their lands and to put their wells in working order. Those who did not conform to this order were warned that the military administration would take over their properties or would put them under contract. Sequestrators, who directed operations under the supervision of the military administration, were named for those companies and enterprises that remained loyal to the allies of Rumania.

* * * By November, 1918, the enemy had restored to production 437 wells out of a total of 962 in existence on July 1, 1916, a proportion of about 45 per cent. * * * This proves that the German military administration concentrated all its efforts on the richest wells that had been salvaged and restored to productivity. Out of 341 wells drilling on July 1, 1916, the Germans continued work on 220.

Petroleum produced in Rumania in 1914–1918, in metric tons.[a]

Year.	Prahova.					Dambovitza.	Bacau.	Buzeu.	Total.
	Bustenari-Calinet-Bordeni.	Campina Poiana.	Moreni.	Other.	Total.				
1914	293,987	174,513	896,096	171,931	1,536,527	49,168	49,837	148,415	1,783,947
1915	286,035	120,657	741,163	283,437	1,431,292	100,824	28,931	112,098	1,673,145
1916[b]	236,950	80,000	530,000	203,073	1,050,023	72,670	25,000	96,400	1,244,093
1917[c]	52,000	77,905	224,350	65,221	419,476	27,376	56,000	14,639	517,491
1918[c]	166,936	97,496	494,650	191,090	950,172	161,299	42,205	60,543	1,214,219

[a] 1 metric ton=7.19 barrels of 42 gallons. [b] Up to time of evacuation by Rumania. [c] Estimated.

BRITISH ISLES.

Particular interest attaches to the search for oil in Great Britain, not only from the great advantages that would accrue to Great Britain from the production of oil within the country itself but also because of the great scientific interest which has been taken in the drilling for oil in that country. An agreement was made between the ministry of munitions and Messrs. S. Pearson & Sons, bearing date of September 10, 1918, wherein it was laid down that the petroleum development managers should commence the development of not exceeding 30 areas for the purpose of production of petroleum, after they had been examined by Sir John Cadman, the firm of S. Pearson & Sons acting as petroleum development managers. In all, 11 drilling sites were selected, of which 7 were in Derbyshire, 2 in

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North Staffordshire, and 2 in the Mid-Lothian district of Scotland. Two wells were begun in 1918 in Derbyshire—the Hardstoft well on October 15 and the Brimington well on November 29, 1918.

Oil shale produced in Great Britain, 1908–1917.

Year.	England.		Scotland.		Wales.		Total.	
	Quantity (long tons).	Value.	Quantity (long tons).	Value.	Quantity (long tons).	Value.	Quantity (long tons).	Value.
1908			2,892,039	$3,870,118			2,892,039	$3,870,118
1909	40	$34	2,967,017	3,970,723			2,967,057	3,970,757
1910			3,130,280	4,189,114			3,130,280	4,189,114
1911			3,116,803	4,171,174			3,116,803	4,171,174
1912			3,184,926	3,726,425			3,184,926	3,726,425
1913			3,279,703	4,001,939	240	$341	3,280,143	4,002,180
1914			3,268,435	4,074,190	231	282	3,268,666	4,074,472
1915	5,976	6,779	2,992,676	4,064,601			2,998,652	4,071,280
1916			3,009,232	5,023,659			3,009,232	5,023,659
1917	1,129	4,901	3,116,529	6,224,253			3,117,658	6,229,154

ITALY.

The following statistics are taken from the Rivista del servizio minerario:

Petroleum produced in Italy, 1909–1918.

Year.	Number of wells in operation.	Quantity.		Value.	
		Metric tons.[a]	Barrels of 42 gallons.	Lire.[b]	Dollars.
1909	12	5,895	42,388	1,178,660	227,481
1910	9	7,069	50,830	1,413,800	272,863
1911	9	10,390	74,709	1,454,600	280,737
1912	9	7,479	53,778	1,196,640	230,952
1913	9	6,564	47,198	1,641,000	316,713
1914	7	5,542	39,849	1,385,500	267,402
1915	7	6,105	43,898	1,712,700	330,551
1916	7	7,035	50,585	4,382,900	845,900
1917	6	5,669	40,763		
1918[c]	6	5,000	35,953	4,000,000	772,000

[a] 1 metric ton, crude=7.1905 barrels. [b] 1 lira=$0.193. [c] Estimated.

GERMAN EMPIRE.

Petroleum produced in the German Empire, 1909–1918.

Year.	Alsace-Lorraine.	Prussia.	Total.		Total value.	
	Metric tons.	*Metric tons.*	*Metric tons.*	*Barrels (42 gallons).*	*Marks.*	*Dollars.*
1909	[a] 29,726	113,518	143,244	1,018,837	10,116,000	2,408,064
1910			145,168	1,032,522	10,146,000	2,414,748
1911			142,992	1,017,045	10,045,000	2,390,710
1912			144,961	1,031,050	10,190,000	2,425,220
1913[b]			140,000	995,764	9,790,285	2,330,088
1914[b]			140,000	995,764	9,790,285	2,330,088
1915[b]			140,000	995,764	9,790,285	2,330,088
1916[b]			140,000	995,764	9,790,285	2,330,088
1917[b]			140,000	995,764	9,790,285	2,330,088
1918[b]			100,000	711,260		

[a] Includes Bavaria. [b] Estimated.

1 metric ton, crude=7.1126 barrels.

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PERSIA.

The following extract is from the report of the chairman of the board of directors of the Anglo-Persian Oil Co. (Ltd.), as recorded in the Petroleum Times of March 29, 1919:

The wells in the field from which we have hitherto been obtaining our production still maintain their extraordinary high rate of yield, and the wells already drilled are, it is estimated, capable of yielding a production at the rate of 5,000,000 tons per annum. On the field adjacent to it, to which I referred at the last meeting, another well at a distance of about 1 mile from the preceding one, has struck oil in considerable volume, the well being reported upon as being equal to any yet struck in the company's territories. In the third field, referred to in my last speech, little progress has since been made, owing to the lack of drilling material, but the prospects are still satisfactory. Testing operations are being carried on, or are about to be started, in a further six fields, all of which give promise of favorable results. You will also be interested to learn that we are now substituting electric for steam power in our producing fields—a change which will result in greater efficiency and a minimum of cost for drilling and producing generally.

Since I last addressed you the first of the refinery extensions at Abadan, to which I then referred, has been completed and brought into operation. The further extensions, for which capital was issued a little over 12 months ago, have not yet been completed, owing to the great delay which has been experienced in obtaining delivery of plant, but they are now well in hand and should be completed during the year. A further large addition at Abadan has now been decided upon to enable us to meet the rapidly growing demand in the East for our fuel oil and will be undertaken as soon as plant can be contracted for at reasonable prices and delivery.

In addition to our extensions at Abadan, we have now commenced the erection of a large refinery near Swansea, where the refining of such products as are marketable in the United Kingdom can be carried on more thoroughly and more economically than at Abadan. The work at this refinery, the initial capacity of which will, I may mention, be twice that of the whole of the Scotch shale oil companies, is being executed with all possible speed.

The additional pumping stations referred to by me at the last meeting are now in course of erection, and should be in operation during the course of this year. We have also decided upon the laying of an additional 10-inch line from the fields to our present 8-inch line, in place of the present 6-inch line, which will further considerably augment our pipeage capacity between the fields and the Persian Gulf. We shall, when this line is completed, have one complete 10-inch line from the fields to the Gulf and another line made up of 10-inch pipe for about half the distance and 8-inch for the remainder.

Our fleet now amounts to a total dead-weight capacity of 162,000 tons, and, as mentioned in the report, we have placed orders for further vessels of a total capacity of about 150,000 tons. We also purpose purchasing further ready tonnage whenever opportunities occur for securing it at reasonable prices. All of our vessels which were requisitioned by the Shipping Controller have now been released, and such as are not required at the moment for our own transport work have been chartered at remunerative rates.

Petroleum produced in Persia, 1917 and 1918.

Year.	Barrels.	Metric tons.
1917	6,856,063	952,231
1918	7,200,000	[a] 1,000,000

[a] Estimated.

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BRITISH INDIA.

The following report concerning the development of the oil industry in India is taken from the annual report of the chairman of the board of directors of the Burmah Oil Co. (Ltd.), as published in the Petroleum Times of June 28, 1919:

Principally on account of the enforced curtailment of our drilling and testing program I have really not very much to say to you to-day in connection with our field operations. In common with all the other oil companies operating in Burma, our efforts during the year were mainly concentrated on the Beme district in the Yenangyoung field, where, as I told you last year, an unexpectedly rich sand was struck at about 2,500 feet. Already, however, the territory is showing signs of the severe drain that has been put upon it, and though some wells still come in with large initial production, they as a rule fall off very rapidly. In regard to our crude oil position generally, though I feel it is rather superfluous for me to say anything on that subject in view of what I have said on more than one occasion in recent years, I can to-day confidently say that our drilling operations every year go to still further strengthen our belief that in our proved oil lands in Burma we have ample reserves of oil to enable us to carry on our refining operations on their present scale for very many years to come.

Of our field operations without Burma I much regret that I can not give you anything in the nature of cheering or encouraging news. We have finally abandoned one of the districts we were testing in India, after drilling to a depth of 2,660 feet without finding any oil. In another district under test in India we have reached a depth of fully 1,300 feet without encountering any oil. In the district in Assam, where, to begin with, we struck oil in fair quantities but of very poor quality and where during the past two years we have been struggling against water difficulties in every well, it has at last been conclusively proved that, owing to the poor quality of the oil, the small production per well, and the presence of so much water with the oil, the field can not be made to pay under present conditions and that the only hope of success lies in the possibility of striking oil in much larger quantities and free from water troubles at greater depths, and we are now arranging to test this possibility by drilling deeper.

Petroleum produced in India, 1909–1917.

Year.	Quantity.		Value.	
	Imperial gallons.	Barrels (42 United States gallons).	Rupees.[a]	Dollars.
1909	233,678,087	6,676,517	13,652,580	4,429,352
1910	214,829,647	6,137,990	12,538,905	4,068,039
1911	225,792,094	6,451,203	13,265,970	4,303,923
1912	249,083,518	7,116,672	14,629,170	4,746,190
1913	277,555,225	7,930,149	15,518,790	5,035,803
1914	259,342,710	7,409,792	14,378,475	4,664,857
1915	287,093,576	8,202,674	18,852,045	6,116,232
1916	297,189,787	8,491,137	16,791,075	5,447,584
1917	282,759,523	8,078,843	16,394,460	5,318,909
1918	280,000,000	8,000,000	.....	.....

[a] The value of the rupee is taken as 32.44⅓ cents; 15 rupees=£1.

Petroleum produced in India, 1914–1918, in imperial gallons.

Province.	1914	1915	1916	1917	1918[a]
Burma	254,652,963	282,291,932	291,769,083	272,795,191	269,000,000
Eastern Bengal and Assam	4,688,547	4,550,150	5,236,890	9,344,815	10,000,000
Punjab	1,200	251,494	183,814	619,517	1,000,000
	259,342,710	287,093,576	297,189,787	282,759,523	280,000,000

[a] Estimated.

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JAPAN AND FORMOSA.

The production of petroleum in Japan and Formosa in 1918 amounted to 2,449,069 barrels, a decrease of 433,309 barrels, or 15 per cent, as compared with the output in 1917. The decrease was due primarily to the suspension of wildcat drilling on account of the shortage of drilling material and casing. With the removal of the export restrictions by the United States at the close of the war, plans were under way for further explorations, and it is to be assumed that production will soon return to normal.

Prices of petroleum and petroleum products in Japan advanced very markedly during the war. The following table of average prices is published by the Petroleum Times (Sekivu-Jiho) of Tokyo (February, 1919, p. 2):

Average prices of petroleum products in yen per koku in 1916, 1917, and 1918.

	Naphtha.	Kerosene.	Neutral.	Fuel oil.	Lubricating oil.
	Yen.	*Yen.*	*Yen.*	*Yen.*	*Yen.*
1916	28.00	19.25	11.25	4.00	11.35
1917	32.00	19.50	12.00	7.00	12.00
1918	44.00	25.00	18.00	15.00	30.70

1 yen=49 cents. 1 koku=47.6 United States gallons=1.136 United States barrels.

The following figures are reported by the Imperial Mining Bureau of the Department of Agriculture and Commerce, Tokyo:

Petroleum produced in Japan and Formosa, 1914–1918, in koku.[a]

	1914	1915	1916	1917	1918
Akita	625,719	989,233	879,188	874,484	835,492
Hokkaido	6,270	8,846	6,627	5,763	7,572
Niigata	1,761,792	1,728,687	1,733,934	1,642,662	1,302,905
Shizuoka	2,055	1,720	1,646	1,551	1,373
Yamagata				220	247
Others				215	181
	2,395,836	2,728,476	2,621,395	2,524,965	2,147,770
Formosa	14,708	16,651	16,966	12,340	8,101
Grand total	2,410,544	2,745,127	2,638,361	2,537,305	2,155,871

[a] 1 koku=39.7 English gallons=47.6 United States gallons=1.136 United States barrels.

Petroleum produced in Japan and Formosa, 1909–1918.

Year.	Japan.		Formosa.		Total.	
	Koku.	*Barrels.*	*Koku.*	*Barrels.*	*Koku.*	*Barrels.*
1909	1,657,036	1,882,398	5,664	7,170	1,662,700	1,889,563
1910	1,520,458	1,727,240	3,208	4,062	1,523,666	1,731,302
1911	1,529,599	1,737,618	1,442	1,638	1,531,035	1,739,256
1912	1,458,290	1,656,617	3,040	3,454	1,461,330	1,660,071
1913	1,693,582	1,923,909	15,933	18,100	1,709,515	1,942,009
1914	2,395,836	2,721,670	14,708	16,708	2,410,544	2,738,378
1915	2,728,476	3,099,549	16,651	18,915	2,745,127	3,118,464
1916	2,621,395	2,977,905	16,966	19,273	2,638,361	2,997,178
1917	2,524,965	2,868,360	12,340	14,018	2,537,305	2,882,378
1918	2,147,770	2,439,867	8,101	9,202	2,155,871	2,449,069

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Output of products of refined oil in Japan in 1917 and 1918, in koku.[a]

Product.	1917	1918	Increase or decrease.
Gasoline	112,359	126,011	+ 13,652
Kerosene	473,236	279,823	−193,413
Neutral	418,741	452,822	+ 34,081
Residuum	626,123	422,999	−203,124
Lubricant	325,880	365,755	+ 39,875
Distillate	.....	115,545	+115,545
	1,956,339	1,762,955	−193,384

[a] From Petroleum Times (Sekiyu-Jiho) of Tokyo, June, 1919, p. 2.

AFRICA.

EGYPT.

The following report concerning the production of petroleum in Egypt is taken from the Petroleum Times, July 5, 1919, page 8:

The total production of crude oil for the year amounted to 277,300 tons, as compared with 134,500 tons in 1917.

The increase in the production has necessitated the creation of more storage and refining facilities on the Hurghada fields and at Suez. Some of these have been completed and others are still in course of erection. Another unit is also being added to the refinery at Suez, the material for which is already on the way to Egypt.

Although so far the results have improved from year to year, your directors wish again to emphasize the fact that the present concessions of the company are very limited in extent and that, if a lasting oil industry is to be built up in Egypt, the larger areas for which application has been made to the Egyptian Government are essential. Our views on this subject have been laid before the Egyptian Government, and when the conditions in the country are more settled it is hoped that the question may become the subject of active negotiations and that a satisfactory settlement may be reached.

Petroleum produced in Egypt, 1911–1918.

Year.	Metric tons.	Barrels of 42 gallons.
1911	1,220	9,150
1912	27,454	205,905
1913	12,618	94,635
1914	103,605	777,038
1915	34,961	262,208
1916	54,800	411,000
1917	134,500	1,008,750
1918	277,300	2,079,750

OCEANIA.

DUTCH EAST INDIES.

The production of petroleum from the Dutch East Indies in 1918, as reported by De Bataafsche Petroleum Maatschappij, was 13,284,936 barrels, a slight increase as compared with the production in 1917. Marked decrease is reported from Java and Sumatra and an increase from Borneo. The portion of the oil produced in the three islands is as follows: Borneo, 60 per cent, Java, 12 per cent, Sumatra, 27 per cent.

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Petroleum produced in Dutch East Indies, 1909–1918.

Year.	Borneo.		Java.		Sumatra.		Total.		
	Metric tons.	Liters.	Metric tons.	Liters.	Metric tons.	Liters.	Metric tons.	Liters.	Barrels.
1909..	411,506	455,922,397	140,351	162,846,428	922,894	1,136,720,015	1,474,751	1,755,488,840	11,041,852
1910..	633,472	701,853,114	142,503	165,344,877	719,740	886,505,130	1,495,715	1,753,703,121	11,030,620
1911..	814,707	902,654,621	172,438	190,766,435	683,523	841,895,279	1,670,668	1,935,316,335	12,172,949
1912..	671,662	744,167,950	184,989	214,641,699	621,481	765,481,929	1,478,132	1,724,291,578	10,845,624
1913..	797,059	[a] 883,061,666	207,135	240,334,598	529,947	652,735,720	[a]1,534,223	1,776,227,127	11,172,294
1914..	[c]931,903	1,032,455,334	226,590	262,907,845	475,423	585,578,509	[b]1,634,403	1,881,506,744	11,834,802
1915..	[d]960,896	1,064,576,678	256,838	298,003,995	491,611	605,517,269	[c]1,710,445	1,969,316,632	12,386,800
1916..	[f]1,047,462	1,160,483,150	243,442	282,460,884	526,080	647,972,736	[g]1,820,247	2,094,531,848	13,174,399
1917..	[h]946,737	1,048,889,923	246,126	285,575,408	583,384	718,554,073	[i]1,778,495	2,055,509,963	12,928,955
1918..	[j]1,072,140	1,187,823,906	241,212	279,873,459	519,989	640,470,451	[k]1,836,914	2,112,105,293	13,284,936

[a] Includes 82 metric tons produced in Ceram.
[b] Includes 487 metric tons produced in Ceram.
[c] Includes 65,185 metric tons produced in British Borneo.
[d] Includes 67,000 metric tons produced in British Borneo.
[e] Includes 1,100 metric tons produced in Ceram.
[f] Includes 90,067 metric tons produced in British Borneo.
[g] Includes 3,263 metric tons produced in Ceram.
[h] Includes 77,614 metric tons produced in British Borneo.
[i] Includes 2,248 metric tons produced in Ceram.
[j] Includes 72,714 metric tons produced in British Borneo.
[k] Includes 3,574 metric tons produced in Ceram.

1 gallon Borneo crude=7.5322 pounds.
1 gallon Java crude=7.1924 pounds.
1 gallon Sumatra crude=6.7754 pounds.
1 United States barrel=158.985 liters; 1 liter=1.0567 quarts.

AUSTRALIA.

NEW SOUTH WALES.

Oil shale produced in New South Wales, 1909–1818.

Year.	Quantity (long tons).	Value.	Year.	Quantity (long tons).	Value.
1909	48,718	$114,932	1914	50,049	$133,205
1910	68,293	164,955	1915	15,474	62,729
1911	75,104	179,963	1916	17,425	86,487
1912	[a] 86,018	169,208	1917	31,661	177,939
1913	[a] 16,985	36,715	1918	32,395	193,083

[a] Estimated.

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ABRASIVE MATERIALS.[1]

By FRANK J. KATZ.

INTRODUCTION.

Industrial operations employ a great variety of abrasive materials. This chapter is concerned with only those mineral products which, as such or as essential constituents of manufactured products, are used for grinding and polishing and other abrasive operations and as cleansers or detersives. The chapter contains statistics of production, as to both quantity and value, either of the raw material alone or of material that has not been advanced beyond that stage of manufacture at which it is sold by the mine or quarry operator.

Artificial abrasives are included for comparison and because of their strong influence on the industry and markets of natural abrasives.

The statistics here given relate, so far as possible, only to that part of the output of any mineral material that properly enters into the abrasive industries. Thus only a small percentage of the sandstone quarried is used in the manufacture of abrasives, grindstones, and pulpstones, the remainder being used chiefly in the building industry. The segregation of the product is not difficult for sandstone, but there is difficulty in separating the diatomaceous (infusorial) earth which is used strictly for abrasive purposes from that which is used in manufacture of filters or of insulating or fireproofing material, and of this product the total output must be included.

On the other hand, quartz and feldspar, both of which are used as abrasives, are excluded from this discussion because precise separation of these materials according to their uses can not be made. They are used principally for purposes other than abrasive, and therefore they are considered in other chapters.

The preparation of this report has been delayed because the author has been assigned to other duties, which were necessarily given precedence. The delay has, however, made it possible to include certain estimates on the production in 1919, and additional information concerning the industry in 1918.

CONSUMPTION.

Complete figures on the total value of the abrasive materials considered in this report that entered into trade in 1918 are not available because of the refusal of a large manufacturer of artificial abrasives to report production for the second half of the year. This

[1] Miss A. T. Coons and Miss F. E. Taylor have aided in the compilation of statistics in this report. The data on imports and exports were compiled by J. A. Dorsey from the records of the Bureau of Foreign and Domestic Commerce, U. S. Department of Commerce.

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total value may, however, be reported as between $11,000,000 and $12,000,000 and a moderate increase over the $11,334,710 total for 1917. This increase was in domestic natural abrasives and in imports, which combined more than offset a decrease in artificial abrasives.

Among the natural abrasives large gains were shown in grindstones and pulpstones, millstones and chasers, and garnet, and there were gains also in oilstones and scythestones, pumice, and grinding pebbles. These gains were largely attributable to increased prices, although there were increases in the quantities also of some of the commodities, as will be shown in subsequent sections of this report. There was a decline in the domestic production (quantity and value) of emery and corundum, diatomaceous earth, tripoli, and tube-mill lining.

Value of all abrasive materials[a] consumed in the United States, 1908–1918.

Year.	Natural abrasives.	Artificial abrasives.	Imports.	Total value.
1908	$1,074,039	$626,340	$476,073	$2,176,452
1909	1,329,750	1,365,820	653,779	3,349,349
1910	1,406,805	1,604,030	977,718	3,988,553
1911	1,526,763	1,493,040	815,854	3,835,657
1912	1,601,993	1,747,120	898,892	4,248,005
1913	1,648,578	2,017,458	916,913	4,582,949
1914	1,360,042	1,685,410	728,710	3,774,162
1915	1,218,508	2,248,778	540,783	4,008,069
1916	1,664,339	2,935,909	555,850	5,156,098
1917	2,385,165	8,137,242	812,303	11,334,710
1918	2,864,332	[b]6,940,000	1,187,632	10,991,964

[a] Exclusive of feldspar and various forms of quartz. See chapters on feldspar and silica (quartz).
[b] Estimated and not including entire production during latter half of 1918.

Value of abrasive materials imported for consumption in the United States, 1915–1918.

Material.	1915	1916	1917	1918
Millstones and burrstones	$17,027	$19,816	$18,227	$20,017
Grindstones and pulpstones	68,892	63,277	57,950	27,361
Hones, oilstones, and whetstones	14,247	10,614	10,636	6,075
Emery and corundum	271,649	240,737	210,602	614,167
Diatomaceous earth, tripoli, and rottenstone	27,333	37,573	17,864	11,128
Pumice	65,691	116,543	147,278	33,014
Diamond dust and bort	75,944	67,290	349,746	475,870
	540,783	555,850	812,303	1,187,632

NATURAL ABRASIVES.

Under the head of natural abrasives in this report are included millstones and related quarry products (such as chasers and dragtones), grindstones and pulpstones, oilstones and scythestones, corundum and emery, abrasive garnet, diatomaceous (infusorial) earth and tripoli, pumice, and pebbles and lining for tube mills. The difficulty of separating abrasive quartz and feldspar from the quartz and feldspar produced for other purposes has led to their omission from the chapter on abrasives, and such information as appears about them in Mineral Resources will be found in chapters entitled "Feldspar" and "Silica (quartz)."

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Natural abrasives were produced in 1918 in 26 States, which are listed below:

Arkansas.....Oilstones.
California.....Diatomaceous (infusorial) earth, grinding pebbles, and pumice.
Connecticut.....Diatomaceous (infusorial) earth.
Idaho.....Diatomaceous (infusorial) earth.
Illinois.....Tripoli.
Indiana.....Oilstones and rubbing stones.
Kansas.....Pumice.
Kentucky.....Hones.
Maryland.....Millstones.
Michigan.....Grindstones and scythestones.
Minnesota.....Grinding pebbles and tube-mill lining.
Missouri.....Tripoli.
Nebraska.....Pumice.
Nevada.....Diatomaceous (infusorial) earth and grinding pebbles.
New Hampshire.....Garnet and scythestones.
New York.....Diatomaceous (infusorial) earth, emery, garnet, and millstones.
North Carolina.....Corundum, emery, garnet, and millstones.
Ohio.....Grindstones, pulpstones, oilstones, and scythestones.
Oklahoma.....Tripoli.
Pennsylvania.....Grinding pebbles, millstones, and rottenstone.
Tennessee.....Tube-mill lining.
Utah.....Diatomaceous (infusorial) earth and "mineral soap."
Vermont.....Scythestones.
Virginia.....Diatomaceous (infusorial) earth, emery, and millstones.
Washington.....Diatomaceous (infusorial) earth.
West Virginia.....Grindstones and pulpstones.

Value of natural abrasives produced and marketed in the United States, 1914–1918.

Abrasive.	1914	1915	1916	1917	1918
Millstones	$43,316	$53,480	$44,559	$43,489	$92,514
Grindstones and pulpstones	689,344	648,479	766,140	1,147,784	1,776,282
Oilstones and scythestones	167,948	115,175	154,573	168,704	189,033
Emery (also corundum in 1917 and 1918)	2,425	31,131	123,901	241,050	112,878
Garnet	145,510	139,584	208,850	198,327	248,161
Abrasive quartz and feldspar	(a)	(a)	(a)	(a)	(a)
Diatomaceous (infusorial) earth and tripoli	252,327	b167,474	b241,553	b369,556	b224,801
Pumice	59,172	63,185	82,263	84,814	91,178
Grinding pebbles	.....	.....	42,500	72,191	82,851
Tube-mill lining	.....	.....	.....	59,250	46,634
	1,360,042	1,218,508	1,664,339	2,385,165	2,864,332

a See chapters on feldspar and silica (quartz).
b Exclusive of considerable production for special uses upon which the Geological Survey is not at liberty to report. Figures for 1917 revised in 1918.

MILLSTONES.

PRODUCTION.

The value of the millstones (burrstones) and related quarry products—chasers, dragstones, and pavers—sold in the United States in 1918 amounted to $92,514, an increase of 113 per cent as compared with 1917. The production in this country in 1918 was greater than in any other year since the setback in the millstone market in the late eighties, which was due to the introduction of modern grain-milling machinery. This setback has been offset to some extent in the last 20 years by the growing use of millstones for grinding mineral products, such as feldspar, quartz, and pigments.

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American millstones have been and are still for the most part made of quartz sandstones and conglomerates. Some are made of granite. The product recorded in the Survey's reports on mineral resources is only that which has been made for other than purely local use. A small number of stones for local use have been made of hard quartz or other rocks, particularly in the mountain sections of the Southern States.

Millstones and chasers were produced in 1918 in Maryland, New York, North Carolina, Pennsylvania, and Virginia. These States and Alabama are the only ones that have produced millstones in recent years. The value of the output in New York increased about 15 per cent, in Virginia there was also a large increase, and in North Carolina there was a very large increase over 1917; in Pennsylvania, the increase was small.

Value of millstones produced and marketed in the United States, 1913–1918.

State.	1913	1914	1915	1916	1917	1918
Alabama	(a)	(a)	.....	(a)	(a)	.....
Maryland						(a)
New York	$21,987	$16,748	$16,883	$10,287	$22,103	$25,488
North Carolina	8,772	5,164	(a)	(a)	(a)	39,224
Pennsylvania	(a)	(a)	(a)	(a)	(a)	(a)
Virginia	23,530	20,100	23,170	25,752	18,980	(a)
Combined totals	1,874	1,304	13,427	8,520	2,406	27,802
	56,163	43,316	53,480	44,559	43,489	92,514

a Included in "Combined totals."

Value of millstones produced and marketed in the United States, 1909–1918.

1909	$35,393	1914	$43,316
1910	28,217	1915	53,480
1911	40,069	1916	44,559
1912	71,414	1917	43,489
1913	56,163	1918	92,514

IMPORTS.

The value of millstones imported for consumption in the United States in 1918 was a little larger than in any other year since 1913, but less than in 1913 and earlier years. In 1918 there was a small increase in the imports of material in the rough and a larger increase in the imports of finished stones.

Value of burrstones and millstones imported for consumption in the United States, 1913–1918.

Year.	Rough.	Made into millstones.	Total.	Year.	Rough.	Made into millstones.	Total.
1913	$36,276	$3,922	$40,198	1916	$15,495	$4,321	$19,816
1914	14,291	709	15,000	1917	17,048	1,179	18,227
1915	16,045	982	17,027	1918	17,570	2,447	20,017

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MILLSTONE INDUSTRY.

Prior to 1918 the millstone industry underwent little change from year to year. Therefore, the statements made in the reports for 1909 and for 1913 may be consulted to supplement the data for 1918 given here. In those earlier reports descriptive notes were given on the millstone industry in New York and Virginia. The data obtained on the production of millstones in 1918 indicate a change in the industry. In previous years more of the large stones used chiefly for the grinding of mineral products, earths, and pigments had been quarried and manufactured than of the similar stones used chiefly in milling grains. Although the production of large stones appears to have increased when measured by value of product in New York and Virginia, the greater part of the production for 1918 appears to have been in the manufacture of stones for milling. This increase was chiefly notable in North Carolina, and the change was probably due primarily to war conditions, which demanded an increase in the number of small grain-milling establishments or, at any rate, an increase in the capacity of such establishments in some sections of the country. The industry in 1919 remained about as in 1918, and the production is still, as in other years, in the hands of small operators in Ulster County, N. Y., Montgomery County, Va., and Rowan, County N. C.

New York.—For many years Ulster County, N. Y., led in the production of millstones and chasers (stones which run on edge or on a horizontal shaft), but in recent years the State has yielded first place to Virginia in the production of millstones, although still leading in the output of chasers. In 1918 New York held third place in the order of value of total output. Fourteen operators reported production of millstones, and six reported also production of chasers.

Virginia.—Virginia held second place in order of value of total output in 1918. Only two operating firms or individuals reported production, both in Montgomery County.

North Carolina.—North Carolina held first rank in the total output of millstones in 1918. Eight operators reported product valued at $39,224. The stones were made in Rowan County, in the vicinity of Salisbury, and were granite stones, chiefly for grain milling.

Pennsylvania.—In Lancaster County, Pa., a quartz conglomerate that has been known to the trade as Cocalico stone is made into millstones. Two manufacturers reported production in 1918.

Alabama.—Near Dutton, Jackson County, Ala., millstones have been made from sandstones of Pennsylvanian age. None were made in 1918.

Vermont.—A quartz conglomerate rock similar to the New York Esopus grit is found near Fair Haven, Rutland County, Vt. No millstones have been made of this rock in recent years.

Ohio.—At Peninsula, in Summit County, Ohio, a white variety of the Berea sandstone was formerly quarried for the purpose of grinding oatmeal and pearling barley, for which it was said to be especially well adapted. At present no millstones are made from the Berea sandstone.

Other States.—In many other States stones of different varieties and more or less suitable for coarse work are or have been quarried and fashioned for use in local mills.

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GRINDSTONES AND PULPSTONES.

PRODUCTION.

The value of grindstones and pulpstones produced and sold in the United States in 1918 was $1,776,282. This was the largest annual output ever recorded and was an increase of $628,498, or nearly 55 per cent, as compared with 1917. The increase was in both quantity and value of both grindstones and pulpstones.

The States and number of quarries producing grindstones in 1918 were Michigan, 2; Ohio, 19; West Virginia, 3. Ohio, as usual, maintained the leading position in the industry, the value of her output being nearly six times that of Michigan and West Virginia combined. The principal producing regions in Ohio are in Lorain, Cuyahoga, and Washington counties. Some stones are also produced in Holmes, Morgan, and Summit counties. The West Virginia product is obtained chiefly from Jackson County, and there is a small output from Wetzel County. Michigan grindstones are all obtained in Huron County.

The production of grindstones in 1918 amounted to 56,554 short tons, valued at $1,262,602, an increase of 2,122 tons, or 4 per cent, in quantity and of $455,706, or 56 per cent, in value as compared with 1917.

Data on the value of quarry products manufactured into grindstones which have been reported to the Geological Survey for recent years indicate that the common unit of value—that is, the value per short ton—varies 15 to 25 per cent, according to the quality and size of the stones, the smaller stones selling at prevailingly higher prices. Stones range from less than a foot in diameter and less than a pound in weight to 6 and 7 feet in diameter, 1 foot or more in thickness, and between 1¼ and 2 tons in weight. In 1917 the prices of fashioned stones not mounted, as reported by the quarry operators, ranged between $12 and $20 a short ton, but were mostly between $13 and $18. Corresponding figures for 1918 were $16 and $38 as the extremes and $19 to $23 as the predominant prices. The average value of all grindstone material sold in 1917 was $14.82 a short ton, and in 1918 it was $22.33.

Prices for 1919 on small stones increased approximately 10 per cent during the year. On other stones, as marketed unmounted by the producer, prices ranged from $20 to $40 a ton, though the average for the year was between $22 and $25—approximately the same as for 1918, but for some grades a little less than prices at the peak of the war demand late in the summer of 1918.

The American grindstone output is chiefly of two kinds—stones for hand grinding, recutting, and similar work, and stones used for machine grinding in such industries as the manufacture of saws, machine knives, edge tools, and harvester machinery.

The production of grindstones for hand grinding was much retarded during the war, does not appear to have recovered materially, and locally has even further decreased in 1919. On the other hand, the production of grindstones for use in manufacturing was enormously augmented during the war, but in the first half of the 1919 season the demand fell far below normal because of the stoppage of war industries and also because large consumers were well stocked

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by heavy buying during 1918. During the later part of 1919, however, demand and production had been restored to about pre-war level.

The production of grindstones is of course a seasonal industry in that the quarries are open cuts in northern latitudes and the freshly quarried sandstone can not be safely handled in freezing weather.

Pulpstones are heavy grindstones used for grinding wood into fine fiber for making pulp and paper. The standard size of pulpstones for certain types of machines is 27 inches in thickness by 54 inches in diameter and about 2 tons in weight. Machines of other types require stones 54 inches in thickness by 62 inches in diameter and about 4 tons in weight.

Pulpstones in 1918 were made by the International Pulpstone Co., at East Liverpool, Columbiana County, Ohio; by the Smallwood Stone Co., at Empire, Jefferson County, Ohio, and at Opekeska, Monongahela County, W. Va.; by the Ohio Buff Sandstone Co., at Sherodsville, Carroll County, Ohio; by the Cleveland Stone Co., at Peninsula, Summit County, Ohio; and by the American Stone Co., at Littleton, Wetzel County, W. Va. The total output was 2,921 stones, valued at $513,680, an increase of 26 per cent in the number of stones, as compared with 1917, and of 320 per cent over 1915. This notable growth was probably due largely, if not altogether, to the difficulty and high cost of importing stones from Great Britain. (See table of imports below.)

Grindstones and pulpstones produced and sold in the United States, 1915–1918.

Year.	State.	Grindstones.		Pulpstones.	
		Quantity (short tons).	Value.	Quantity (pieces).	Value.
1915	Michigan, Ohio, and West Virginia	42,623	$564,340		
	Ohio			696	$34,139
1916	Michigan, Ohio, and West Virginia	50,839	631,497		
	Ohio			1,066	134,643
1917	Michigan, Ohio, and West Virginia	54,432	806,896		
	Ohio and West Virginia			2,325	340,888
1918	Michigan, Ohio, and West Virginia	56,554	1,262,602		
	Ohio and West Virginia			2,921	513,680

Value of grindstones and pulpstones produced and marketed in the United States, 1909–1918.

1909	$804,051	1914	$689,344
1910	796,294	1915	648,479
1911	907,316	1916	766,140
1912	916,339	1917	1,147,784
1913	855,627	1918	1,776,282

IMPORTS AND EXPORTS.

The value of the imports of grindstones and pulpstones decreased in 1918 to $27,361, which was nearly 53 per cent less than in 1917.

Value of grindstones and pulpstones imported for consumption in the United States, 1913–1918.

1913	$139,386	1915	$68,892	1917	$57,950
1914	109,539	1916	63,277	1918	27,361

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The value of the grindstones exported from the United States in 1918 was $210,889, against $198,772 in 1917 and $176,563 in 1916.

CANADIAN PRODUCTION.[1]

The following table, showing quantity and value of grindstones, pulpstones, and scythestones produced in Canada, is inserted for comparison with the production in the United States and because the Canadian output is to some extent contributory to the domestic supply:

Grindstones, pulpstones, and scythestones produced in Canada, 1908–1918.

Year.	Quantity (short tons).	Value.	Year.	Quantity (short tons).	Value.	Year.	Quantity (short tons).	Value.
1908.....	3,843	$48,128	1912.....	4,412	$52,090	1916.....	3,478	$52,782
1909.....	4,275	54,664	1913.....	4,837	51,325	1917.....	2,523	45,754
1910.....	3,973	47,196	1914.....	3,976	54,504	1918.....	3,072	83,005
1911.....	4,566	52,942	1915.....	2,508	35,768			

OILSTONES AND SCYTHESTONES.

PRODUCTION.

The value of the oilstones, whetstones, hones, scythestones, and rubbing stones produced in the United States in 1918 amounted to $189,033, an increase of $20,329, or 12 per cent, as compared with 1917, and of $34,460, or 22 per cent, as compared with 1916. The output has not yet risen to the value attained prior to 1914.

Oilstones and whetstones were produced in 1918 from several small quarries, whose product was sold to three manufacturers and reported by them from the Hot Springs district of Garland County, Ark.; by two manufacturers in Orange County, Ind.; and by two in Scioto County, Ohio. Production of scythestones was reported by one company in Huron County, Mich.; one in Grafton County, N. H.; one in Cuyahoga County and one in Scioto County, Ohio; and one in Orleans County, Vt. Rubbing stones were produced by two concerns in Floyd County, Ind. The Kentucky Lithographic Stone Co., at Brandenburg, Meade County, Ky., in 1917 obtained in the course of its quarry operations materials from which it manufactured hones, but it reported none in 1918. Products classified as hones were, however, obtained at Elizabethtown, Hardin County, Ky., by the Kentucky Hone Co.

The greater part of the country's output of the products of this group, as reported to the Geological Survey, consisted of oilstones and whetstones chiefly from Arkansas, and next in importance were scythestones from Vermont, New Hampshire, Ohio, and Michigan. The quantities and values of the several commodities produced in 1918 were as follows: Oilstones and whetstones, 559 short tons, valued at $134,376; scythestones, 6,011 gross (weighing approximately 330 short tons), valued at $37,125; hones and rubbing stones, 240,672 pounds, valued at $17,532. The combined quantity

[1] From reports of Canada Dept. Mines.

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was approximately 1,000 short tons. The quantities and values represent products that have for the most part been subjected to finishing and manufacturing processes and are thereby enhanced in value before being sold to consumers, as compared with raw quarry products.

A description of the scythestone industry in New Hampshire was given in this report for 1909, and a description of the Arkansas oilstones, oilstone deposits, and industry was included in the report for 1911.

Value of oilstones and scythestones produced and marketed in the United States, 1909–1918.

1909	[1] $214,019	1913	[1] $207,352	1917	[5] $168,704
1910	[2] 228,694	1914	[3] 167,948	1918	[2] 189,033
1911	[1] 214,991	1915	[4] 115,175		
1912	[1] 232,218	1916	[3] 154,573		

Value of hones, oilstones, and whetstones imported for consumption in the United States; 1913–1918.

1913	$40,222	1915	$14,247	1917	$10,636
1914	33,655	1916	10,614	1918	6,075

CORUNDUM AND EMERY.

SUPPLY.

The sources of the domestic and foreign supply of corundum and emery were briefly summarized in this report for 1917. Little need be added to that statement except that the emery deposits in Pittsylvania County, Va., were successfully exploited during 1918 and yielded a considerable quantity of good material. The better grades of Virginia emery have been tested by use and compare favorably with medium grades of Turkish emery. They are far superior to the emery of Peekskill, N. Y. South African corundum deposits yielded large quantities during 1918 and 1919. This corundum has been found to be of satisfactory grade.

PRODUCTION.

Corundum was produced in 1918 by two operators, one in Macon County and one in Jackson County, N. C.

The domestic emery produced in 1918 came largely from the Peekskill region in Westchester County, N. Y., and from Pittsylvania County, Va. Some emery was also produced in Macon County, N. C. No emery was produced from the mines in Chester, Hampden County, Mass. The production in 1918 was about 10,000 short tons, valued at nearly $75,000 for crude emery f. o. b. mines. This output was 38 per cent smaller than the quantity produced in 1917. The average value of the crude quarry product in 1918 was $7.44 a short ton, a decrease of $3.20, or 30 per cent, as compared with 1917.

[1] Includes a quantity of honestone quarried in Kentucky and "rubbing stone" quarried in Indiana.
[2] Includes a quantity of "rubbing stone" quarried in Indiana.
[3] Includes a quantity of honestone quarried in Kentucky and Pennsylvania and "rubbing stone" quarried in Indiana.
[4] Includes a quantity of honestone quarried in Kentucky and Ohio and "rubbing stone" quarried in Indiana and Ohio.
[5] Includes a quantity of honestone quarried in Kentucky and "rubbing stone" quarried in Indiana and Kentucky.

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Emery produced and sold in the United States, 1907–1918.

Year.	Quantity (short tons).	Value.	Year.	Quantity (short tons).	Value.	Year.	Quantity (short tons).	Value.
1907	1,069	$12,294	1911	659	$6,778	1915	[a] 3,063	[a] $31,131
1908	669	8,745	1912	992	6,652	1916	15,282	123,901
1909	1,580	18,185	1913	[a] 957	[a] 4,785	1917	[b] 17,135	[b] 241,059
1910	1,028	15,077	1914	[a] 485	[a] 2,425	1918	[c] 10,422	[c] 112,878

[a] Estimated. [b] Includes 820 short tons of corundum, valued at $67,461. [c] Includes corundum.

IMPORTS.

The year 1918 was marked by a large increase in the total value of imports of all forms of emery and corundum, amounting to 192 per cent as compared with 1917. The imports have fluctuated irregularly in both quantity and value during the last decade. Because of the war's interference with mining in Turkey and Greece and with shipping the quantity imported in 1917 was far less than in any previous year and probably reached the lowest level.

Emery and corundum imported for consumption in the United States, 1910–1918.

Year.	Grains.		Ore and rock.		Other manufactures.	Total value.
	Quantity.	Value.	Quantity.	Value.	Value.	
	Pounds.		*Long tons.*			
1910	2,311,464	$106,570	28,948	$509,661	$13,527	$629,758
1911	1,382,813	76,027	10,822	245,459	15,158	336,644
1912	2,135,922	105,325	16,391	369,529	16,871	491,725
1913	2,496,372	114,786	17,123	342,809	16,704	474,299
1914	1,781,821	79,989	12,909	280,866	22,581	383,436
1915	1,277,673	56,254	8,462	197,303	18,092	271,649
1916	1,689,689	90,646	7,623	113,176	36,915	240,737
1917	2,207,912	119,033	1,056	50,087	41,482	210,602
1918	4,138,587	231,908	6,677	322,610	59,649	614,167

CANADIAN CORUNDUM.

Canadian corundum shipped, 1913–1918.[a]

Year.	Quantity (short tons).	Value.	Year.	Quantity (short tons).	Value.
1913	1,177	$137,036	1916	67	$10,307
1914	548	72,176	1917	188	32,153
1915	339	37,798	1918	[b] 137	[b] 26,112

[a] Figures taken from the annual reports on mineral production of Canada, Canada Dept. Mines.
[b] Preliminary report on mineral production of Canada during 1918, Canada Dept. Mines, 1919.

ABRASIVE GARNET.

PRODUCTION.

The quarry output of domestic garnet sold for use as abrasive material in the United States in 1918 amounted to 4,696 short tons, valued at $248,161. This was a decrease of 299 tons, or 6 per cent,

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in quantity and an increase of $49,834, or 25 per cent, in value, as compared with 1917, and a decrease of 1,475 tons, or 24 per cent, in quantity and an increase of $39,311, or 19 per cent, in value, as compared with 1916. Prices ranged from $26.53 to $60 a ton, and the average price was $52.85.

The garnet situation remained unchanged with respect to sources of supply and production in 1919 as compared with 1918. The prices, however, were much higher. They ranged between $50 and $80 a ton, chiefly because of the scarcity of labor, which made it costly to meet the demand. During 1919 a few hundred tons of placer garnet was imported from Almeria, Spain.

Abrasive garnet produced and sold in the United States, 1910–1918.

Year.	Quantity (short tons).	Value.	Year.	Quantity (short tons).	Value.
1910	3,814	$113,574	1915	4,301	$139,584
1911	4,076	121,748	1916	6,171	208,860
1912	4,947	163,237	1917	4,995	198,327
1913	5,308	183,422	1918	4,696	248,161
1914	4,231	145,510			

TRIPOLI, DIATOMACEOUS (INFUSORIAL) EARTH, AND ROTTENSTONE.

PRODUCTION.

Tripoli and diatomaceous (infusorial) earth have been combined for consideration in these reports for many years for the reasons that, because of the confusion in names, it was not expedient to make the separation in the earlier canvasses after the beginning of the production of what is now called tripoli and that the uses of the materials as abrasives are in part the same. Since 1913 the production of diatomaceous earth has also been separately reported, but in the statistics of production the Pennsylvania rottenstone has been included with tripoli.

Diatomaceous earth and tripoli produced and sold in the United States, 1910–1918.

Year.	Quantity (short tons).	Value.	Year.	Quantity (short tons).	Value.	Year.	Quantity (short tons).	Value.
1910		$130,006	1913	27,283	$285,821	1916[a]	45,978	$241,553
1911	16,082	147,462	1914	28,230	252,327	1917[a]	29,102	[b] 369,556
1912	16,706	125,446	1915[a]	35,304	167,474	1918[a]	22,947	224,801

[a] Exclusive of considerable production for special uses upon which the Survey is not at liberty to report.
[b] Figures for 1917 revised in 1918.

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Tripoli produced and sold in the United States, 1917–18.

State.	1917			1918		
	Quantity (short tons).	Value.		Quantity (short tons).	Value.	
		Estimated (crude).	As sold (crude and finished.)		Estimated (crude).	As sold (crude and finished.)
Illinois	16,133	$31,338	$207,738	12,004	$18,902	$100,126
Missouri, Oklahoma, and Pennsylvania	9,936	61,078	130,450	7,978	34,913	99,728
	26,069	92,416	338,188	19,982	53,815	199,854

Diatomaceous earth produced[a] and sold in the United States, 1916–1918.

State.	1916[a]		1917		1918	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Western States[b]	1,840	$14,700	2,796	$25,570	2,847	$18,525
Eastern States[c]	881	11,637	237	5,798	118	6,422
	2,721	26,337	3,033	31,368	2,965	24,947

[a] Exclusive of considerable production for special uses upon which the Survey is not at liberty to report.
[b] 1916: California, Nevada, and Washington; 1917: California, Nevada, Utah, and Washington; 1918: California, Idaho, Nevada, Utah, and Washington.
[c] 1916: Connecticut, Maryland, Massachusetts, New Hampshire, and New York; 1917: Connecticut, Maryland, and New York; 1918: Connecticut, New York and Virginia.

Production of tripoli and rottenstone.—The tripoli and rottenstone sold for all purposes in the United States in 1918 amounted to 19,982 short tons, valued at $199,854, a decrease of 6,087 tons, or 23 per cent, in quantity, and of $138,334, or 41 per cent, in value, as compared with 1917. The preceding table, giving the tripoli produced and sold in the United States in 1917 and 1918, shows an apparently large difference in price for tripoli as between Illinois and other States. The product in Illinois, Missouri, and Oklahoma was all similar material, valued in the crude state at $1 to $3.50 a ton f. o. b. quarries. The Pennsylvania output, which in the table has been included with that of Missouri and Oklahoma, consisted of rottenstone, which is valued roughly at $15 a short ton. Much of the output in Illinois, Missouri, and Oklahoma was sold ground or, in Missouri, manufactured into filter stones. The prices received for ground tripoli or tripoli flour ranged from $9 to $18 a ton, and the value of filter stones ranged between $18 and $27 a ton.

In Illinois four mines in Alexander County and three in Union County reported the production of tripoli in 1918. The production was 4,129 tons less than that made in 1917, and the estimated average value of the crude material was $1.57 a ton. Most of the output, however, was sold in ground form at prices ranging from $15 to $18 a ton. The total value of the Illinois output at sale prices was $100,126. In Missouri three operators reported production in Newton County,

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and one operator in Clinton County produced a small quantity of powdered calcareous shale for use as abrasive material which is included with the output of tripoli in Missouri. A large part of the Missouri-Oklahoma output was made into filter stones, and the scrap from the manufacture of filter stones together with the remainder of the output was ground for sale as tripoli flour. Oklahoma deposits of tripoli were not productive, except one that was worked as part of a plant in Newton County, Mo., and therefore separate data for the two States are not available. The rottenstone produced in Pennsylvania came from Antes Fort, Lycoming County. The total value of the output of tripoli and rottenstone in Missouri, Oklahoma, and Pennsylvania in 1918 at sale prices for crude and finished products was $99,728.

Production of diatomaceous earth.—The diatomaceous earth (also called diatomite, infusorial earth, kieselguhr, tripoli, and tripolite, and sold under various trade names) sold in the United States in 1918 amounted in part to 2,965 short tons, valued at $24,947; in addition, there was a considerable production for special uses, upon which the Geological Survey is not at liberty to report. In 1918 the producing States were California, Connecticut, Idaho, Nevada, New York, Utah, Virginia, and Washington. In the table showing production for 1916, 1917, and 1918, by Western and Eastern States, the product in the Eastern States is valued at two to eight times as much a ton as the western product. The difference is due to the fact that the eastern product was largely sold as high-grade cleaning and polishing preparations, whereas the western product was sold as raw quarry product or went into the manufacture of structural materials and insulation. The projected large developments based on the Maryland and Virginia diatomaceous deposits have not been carried out.

IMPORTS.

Value of tripoli, diatomaceous earth, and rottenstone imported for consumption in the United States, 1913–1918.

1913	$28,696	1915	$27,333	1917	$17,864
1914	20,004	1916	37,573	1918	11,128

PUMICE.

The domestic product sold as pumice prior to 1917 was almost wholly a finely comminuted volcanic dust or "ash" composed of minute fragments of pumiceous, glassy lava, not properly called pumice. This material differs very little from the product made by grinding the imported lump or block pumice and may be substituted for it. Very little lump pumice was obtained from domestic sources prior to 1917. In that year, largely because of the difficulty of shipping from Mediterranean ports, a considerable output of good grades of lump pumice was obtained from the vicinity of Mount Shasta and the Salton Sea in California. Efforts were also made to exploit deposits of lump pumice in Coconino County, Ariz. In May, 1918, an embargo was put on all overseas imports of pumice, so that consumers were forced to depend largely on stocks of Italian pumice remaining in this country and on domestic supplies. Fortunately for the consuming industries, the domestic materials, both volcanic dust from the Great Plains region and the western lump pumice, were

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satisfactory for all requirements other than the most exacting, which demand lump of very fine, even texture, free from discrete mineral particles, for lithographic work and for fine finish on copper, silver, and other metals before plating. Probably not more than 100 tons a year of such lump is ordinarily required, and it is possible that these needs might have been met and can again hereafter be met by careful selection from domestic supplies. Furthermore, the situation was relieved because the demand for pumice for finishing work fell off during the war through diminished production in the woodworking industries. This demand has increased since the middle of 1919 and at the end of that year was about the same as before the war. Although there was, during 1919, no restriction on imports, prices for pumice have increased about 10 per cent over prewar prices because of increased ocean freights and increased cost of labor, but even with such increases the cost of imported pumice is less than the cost of domestic pumice. For that reason, and also because the domestic lump is not wholly equal to the Italian pumice for abrasive work and fine finishing work, the California deposits that were opened during the war have been abandoned.

PRODUCTION.

The statistics given represent pumice used for abrasive purposes solely, and those for 1918 include a quantity of lump pumice from California not reported in previous years. The pumice used for building stone and in cement and concrete construction is not included. The material has come from several counties in six States—Humboldt, Inyo, Imperial, and Siskiyou counties, Calif.; Harper, Meade, Morton, and Phillips counties, Kans.; Furnas, Lincoln, and Harlan counties, Nebr.; Custer County, S. Dak.; Cassia and Power counties, Idaho; and Millard County, Utah. Available deposits are very widespread and are particularly abundant in all the Great Plains States from South Dakota to Texas. The Geological Survey received reports of production in 1918 from Humboldt, Imperial, and Siskiyou counties, Calif.; Meade and Harper counties, Kans.; and Furnas and Lincoln counties, Nebr.

The pumice sold or used by these producers in 1918 amounted to 30,637 short tons, valued at $91,178, a decrease of 4,656 tons, or about 13 per cent, in quantity and an increase of $6,364, or 8 per cent, in value, as compared with 1917. In 1918 California produced a small quantity, somewhat larger than in 1916 or 1917. The production in Kansas decreased from that of the preceding year and again far exceeded that from Nebraska, which for a number of years prior to 1916 had been the leading State; and the production in Nebraska was less in 1918 than in 1917.

Pumice produced and sold in the United States, 1910–1918.

Year.	Quantity (short tons).	Value.	Price per ton.	Year.	Quantity (short tons).	Value.	Price per ton.
1910	23,271	$94,943	$4.08	1915	27,708	$63,185	$2.28
1911	21,689	88,399	4.08	1916	33,320	82,263	2.47
1912	27,146	86,687	3.19	1917	35,293	84,814	2.40
1913	24,563	55,408	2.26	1918	30,637	91,178	2.98
1914	27,591	59,172	2.14				

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IMPORTS.

Value of pumice imported for consumption in the United States, 1913–1918.

1913	$93,408	1916	$116,543
1914	92,668	1917	147,278
1915	65,691	1918	33,014

PEBBLES FOR GRINDING.

Pebbles used for grinding minerals, ores, cement ingredients and clinker, and other materials may be properly considered abrasive materials. This report prior to 1914 had not included them, because none had been produced in the country except small quantities for local use, of which no record was obtained, and also because the records of imports of foreign pebbles for grinding are not kept separate from those of pebbles that are crushed and used as "flint" in the ceramic industry. The chapters of Mineral Resources on quartz or silica have annually given the quantity of the pebbles imported both for grinding and as flint. Little or no interest had been taken in domestic sources of grinding pebbles until the fall of 1914, when the threatened interruption of imports from Denmark and France, the principal sources of foreign supply, aroused American jobbers and consumers to become independent.

DOMESTIC SUPPLY.

Information on domestic sources of flint or other pebbles used for grinding and of substitutes for such pebbles is summarized in the reports on abrasive materials in Mineral Resources for 1914 and 1916. A recent publication[1] by the Survey describes pebble deposits in Pike, Howard, and Sevier counties, Ark.

In 1918, as in 1917, pebbles for grinding ores, minerals, and clinker were obtained from beaches between Oceanside and Encinitas, San Diego County, Calif. These were gathered and marketed by three or more firms and individuals, whose names and addresses may be obtained from the Geological Survey. These pebbles are gaining in favor in metallurgic and cement plants. Omer Maris, of Manhattan, Nev., continued through 1918 the manufacture of "artificial pebbles" (mechanically smoothed and rounded rock blocks) and supplied metallurgic plants in the vicinity of his plant. The Jasper Stone Co., of Sioux City, Iowa, began a new enterprise during 1917—the manufacture for use as pebbles of 3-inch to 5-inch cubical blocks from the quartzite at its quarry in Rock County, near Jasper, Minn. These cubes are reported to be satisfactory, as they are both very hard and very tough and are said to wear very slowly after the corners and edges are chipped off.

PRODUCTION.

Sales of pebbles, cubes, and artificially rounded blocks for grinding amounted in 1918 to 9,934 short tons, valued at $82,851, a decrease of 17 per cent in quantity as compared with 1917. Besides this marketed output there was a considerable consumption of

[1] Miser, H. D., and Purdue, A. H., Gravel deposits of the Caddo Gap and De Queen quadrangles, Ark.: U. S. Geol. Survey Bull. 690, pp. 15–30, 1918.

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substitutes for grinding pebbles by mills that used local pebbles or boulders, lumps of ore, or native rock. The production from all domestic sources in 1919 was far less than in 1918, chiefly because of adverse freight rates, the growing use of steel and iron balls, and a reduction in the quantity of gold and silver ores milled in plants that have used domestic pebbles. Consumers now demand a high degree of roundness and freedom from flaws, which increase the labor cost of producing pebbles. High freight rates have driven some consuming companies to use local material, although such material is generally poor and inefficient.

IMPORTS.

The exact quantity of flint pebbles annually imported for use in grinding is not determinable from reports of the Department of Commerce, as only the total invoice value of imported pebbles of all kinds combined is recorded.

In the accompanying tables are given the value both of "imports for consumption" and of "general imports" classified according to countries of origin.[1] Both groups of figures are of interest to the present discussion.

Value of general imports of pebbles and flint into the United States, 1913–1918.

	1913	1914	1915	1916	1917	1918
Belgium	$40,947	$70,851				
British India				$2,440		
Canada	8,599	63,996	$1,128			$700
Denmark	134,625	193,029	152,129	175,916	$122,883	86,664
England	2,626	2,199	1,303			
France	121,854	116,571	91,024	117,649	65,311	38,519
Germany	2	91				
Italy		22			39	
Japan		12	97	7,924		
Newfoundland and Labrador	10,900	8,448				
Norway		1,846		1,780		
Portugal				214		
Sweden	56	22,681	28,668	7,197	7,744	1,925
	319,509	479,146	273,769	313,120	196,977	127,808

Value of pebbles and flint imported for consumption in the United States, 1910–1918.

1910	$307,286	1915	$274,904
1911	236,158	1916	313,120
1912	289,904	1917	197,156
1913	324,662	1918	127,808
1914	432,694		

TUBE-MILL LINING.

"Flint liners" for tube mills are dimension blocks cut from flint or other hard siliceous rock. Before the war almost the entire supply for domestic consumption was imported from Belgium. High prices and the very considerable inconvenience in procuring liners from Europe have developed a domestic supply. During 1918 liners were produced and sold by the American Flint Co., Iron City, Tenn.,

[1] These figures are not identical, because merchandise brought into the country and listed under "general imports" may be put into a warehouse and not be withdrawn for consumption during the calendar year of entry. It is credited "for consumption" to the year of its withdrawal from the warehouse.

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and the Jasper Stone Co., Sioux City, Iowa. The output was less than in 1917. Products of these concerns appear to be satisfactory substitutes for the materials formerly imported.

ARTIFICIAL ABRASIVES.

The artificial abrasives here considered are of three kinds—(1) metallic abrasives, manufactured by the Pittsburgh Crushed Steel Co., Pittsburgh, Pa., and including "diamond crushed steel" (crushed crucible steel), "angular grit" (crushed chilled iron), and "crushed cast iron"; (2) silicon carbides, including carborundum, manufactured by the Carborundum Co., at Niagara Falls, N. Y.; crystolon, manufactured by the Norton Co., at Chippewa, Ontario; and carbolon, manufactured by the Exolon Co., at Thorold, Ontario, and Blasdell, N. Y.; (3) aluminum oxides, including alundum, manufactured by the Norton Co., at Niagara Falls, N. Y., and Chippewa, Ontario; aloxite, manufactured by the Carborundum Co., at Niagara Falls, N. Y., Niagara Falls, Ontario, and Shawinigan, Quebec; exolon, manufactured by the Exolon Co., at Blasdell, N. Y., and Thorold, Ontario; lionite, manufactured by the General Abrasives Co. (Inc.), at Niagara Falls, N. Y.; coralox, manufactured by the D. A. Brebner Co. (Ltd.), at Hamilton, Ontario; and natite, manufactured by the National Abrasive Co., at Hamilton, Ontario.

So far as known to the Geological Survey, these are the only artificial abrasives manufactured in North America. Artificial abrasives sold under other names are merely the above-named products marketed under special trade names or are imported products.

In the following table the quantity and value reported for 1918 are incomplete estimates, as certain figures on production during the second half of the year have not been obtained from a producing company.

Artificial abrasives produced in the United States and Canada, 1910–1918.

Year.	Quantity (pounds).	Value.	Year.	Quantity (pounds).	Value.
1910	23,027,000	$1,604,030	1915	37,684,000	$2,248,778
1911	21,292,000	1,498,040	1916	77,612,000	2,935,909
1912	29,002,000	1,747,120	1917	115,822,000	8,137,242
1913	33,489,000	2,017,458	1918[a]	87,600,000	6,940,000
1914	27,191,611	1,685,410			

[a] Not including entire production during second half of 1918.

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STONE.

By G. F. Loughlin and A. T. Coons.

HISTORICAL REVIEW OF THE STONE INDUSTRY.[1]

The whole country appears to have entered upon a process of general reconstruction in which the mineral industries are involved. Hence it seems appropriate to begin this report with a brief historical review of the changes that have taken place in the stone industry particularly in late years. It must be borne in mind, however, that no previous period is strictly comparable to the present, although the period that followed the Civil War was similar in some respects, and the revival in the building industries beginning about 1896 may fairly be considered as the industrial precursor of the revival that appears to have begun in the fall of 1919.

BEFORE THE CIVIL WAR.

The stone industry in this country, which began with the utilization of boulders and cobbles in Colonial times, was confined almost exclusively to the building and monumental trades for many years. Limestone was quarried for burning lime and for fluxing the small quantity of iron ore then mined, but granite paving blocks were not used until 1840, and the use of crushed stone, though demonstrated by Macadam about 1820, did not make much headway in this country until after the Civil War. Other modern extensive uses of stone, particularly of limestone as a chemical reagent in many manufacturing industries and of dolomite and quartzite for refractory products, were little realized. Ganister bricks from quartzite were first made near Sheffield, England, in 1858–59.[2] This lack of use of stone in the earlier years, including the first quarter of the nineteenth century, was the result, doubtless, of the abundance of timber and brick clay in the present Eastern States. During that period granite cut from boulders in eastern Massachusetts and New Hampshire furnished the principal building stone in those regions. The brown sandstones in Connecticut and probably New Jersey supplied local demands. The light-gray sandstone of Aquia Creek, Va., had gained prominence because of its use in the White House, Capitol, and other buildings in Washington during the very first years of the century and was shipped by water as far as Boston in 1820. This was probably the first stone of more than local importance. It was of a color that would find favor now, but its poor weathering quality brought it into

[1] Abridged in part from a text by Mr. Loughlin, forming a chapter in the "History of the mineral industries," compiled by E. W. Parker for the Carnegie Institution.
[2] Quarry, July, 1919, p. 184.

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disrepute and it has not been quarried to any extent since 1840. The stone still in use has been preserved from further weathering by painting its surface. Marble quarried in Vermont, Massachusetts, Pennsylvania, and Maryland was used for tombstones, sills, steps, and a few monuments during the early part of the century, but no marble-faced building was erected until 1854. Limestone and sandstone were also used locally for buildings and tombstones in New York, Pennsylvania, Maryland, and States farther west. The oolitic limestone of Indiana found local use as early as 1819.

During the second quarter of the century quarries were opened in several States and Territories, even as far west as California, and the building-stone industry made marked progress. Systematic granite quarrying began in 1825, largely as a result of improved methods of quarrying and handling large blocks at Quincy, Mass., for the erection of Bunker Hill Monument, and this led to the construction of many granite buildings in Boston, New York, Philadelphia, and other cities. The Quincy granite, owing, no doubt, to its reputation gained as the stone used in Bunker Hill Monument, to its favorable position near tidewater, and to the more advanced methods of quarrying it, was probably the leading building granite during this period, although other granites, quarried along the coast of Maine and Massachusetts, were finding an equally extensive range of markets. Other New England granites, now well known, were supplying mostly local demands, which included a few important buildings, such as the State capitols of New Hampshire and Vermont.

The marble industry continued to develop slowly during the second quarter of the century, furnishing principally tombstones. Limestones and most sandstones continued to supply local demands, but the brownstones attained national prominence and the famous brownstone fronts had begun their invasion of New York.

Toward the middle of the century railroads attained a considerable growth and began to afford a means whereby stones of superior architectural merit were admitted to hitherto inaccessible markets. Thus Vermont and Massachusetts marbles displaced the marble of Montgomery County, Pa., as early as 1840, and the gray and buff sandstones of northern Ohio made their appearance in New York in 1857, beginning to compete with the brownstones of Connecticut and New Jersey and with the brown and white sandstones of Medina, N. Y., which had previously been shipped by water to cities in Ohio and Michigan.

Street paving was done with cobblestones from Colonial times until about 1850. Granite paving blocks were introduced into Boston in 1840, into Philadelphia in 1848, and into New York about 1850. The blocks first used were considerably larger than the modern blocks, their surfaces measuring a square foot or more in area; but repeated experience soon resulted in the adoption of blocks essentially like those used to-day.[8]

The date when flagstones for sidewalks and crossings were introduced is not definitely known, but it was probably early in the nineteenth century, as the mica schist quarries of Bolton and Vernon, Conn., had already been considerably developed by 1837. This stone was not well situated for economical quarrying, and it may have been

[8] Braley, A. W., History of the granite industry of New England, vol. 1, pp. 167—170, Boston, 1913.

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this fact as well as the softness of the stone compared with granite and the well-known Hudson River flagstones that caused these quarries to be abandoned long ago, perhaps before the Civil War. This mica schist was used extensively in Hartford, Conn., 12 miles from the quarries, and to some extent in Boston, and perhaps in New York and elsewhere. It is still to be seen in Hartford. The Hudson River bluestone was probably quarried as early as 1840 in Ulster County, N. Y. Granite flaggings, principally from Quincy and Rockport, Mass., were probably introduced before the Civil War, and flaggings from granite quarries along the coast of Maine were probably used in Boston and other cities along the Atlantic coast not long afterward.

The stone quarries had increased considerably in number by 1860 but still supplied chiefly a local demand. The only other noteworthy feature was a marked growth of the Vermont marble industry between 1850 and 1860, and the use of marble for the facing of buildings as well as for trimmings and tombstones. The brownstones reached the culmination of their popularity in New York from 1840 to 1860, though they were used extensively for some time afterward.

According to the Seventh and Eighth Census reports, stone produced at the leading quarries was valued at $8,180,115 in 1850, and at only $4,265,899 in 1860. This apparent decline of nearly 50 per cent may have been due in part to failure to obtain returns from many important producers and in part to unsettled conditions just before the Civil War. The difference may also have been due in part to the inclusion of figures from stone-cutting plants in 1850. The total value of the output reported from such plants in 1860 was $16,244,044. Quarry production in 1860 was reported from only 18 States, as follows:

Principal stone-producing States in 1860.

State.	Value of product (eighth census).	Principal kinds of stone.
Vermont	$715,550	All marble.
New York	647,357	Sandstone, limestone, granite (gneiss).
New Jersey	580,727	Brownstone.
Connecticut	532,704	Sandstone mostly, some granite.
Pennsylvania	418,591	Gneiss, sandstone, serpentine, and limestone.
Maryland	346,900	Marble ($300,000), brownstone, granite.
Maine	295,280	Granite.
Massachusetts	289,626	Granite, marble ($122,496), "puddingstone."
Missouri	230,376	Limestone, sandstone(?).
Illinois	64,148	Limestone, sandstone.
Ohio	63,600	Sandstone, limestone.
Indiana	37,800	Limestone.
New Hampshire	23,540	Granite.
Rhode Island	6,800	Granite.
Michigan	6,550	Sandstone, limestone.
Wisconsin	3,800	Sandstone, limestone (granite?).
Delaware	2,000	Granite, gabbro-diorite.
Iowa	550	Gypsum, limestone.
	4,265,899	

Of the total value, $1,863,500, or 44 per cent, was from the New England States; $1,995,575, or 47 per cent, from the Middle Atlantic States; and $406,824, or 9 per cent, from the "Western States," only two of which were west of Mississippi River.

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These figures, though doubtless incomplete, show some interesting contrasts not only in values of output from the present important States, but in the relative value of different kinds of stone. Vermont, then as now, was the leading State in the production of marble, which was used for both monumental and building work, but produced no granite of more than local importance. The production of marble in Massachusetts and Maryland was relatively more important then than in recent years and exceeded their outputs in 1917 and 1918. Production from several marble quarries in Massachusetts and Connecticut, as well as Pennsylvania, had already declined or ceased, owing to the growing popularity of Vermont marble as well as marble imported from Italy. Marble then supplied about all the demand for monumental stone, granite being little used for this purpose until after 1860. New Jersey and Connecticut owed their prominence to brownstone, whereas in 1917 the value of the output of sandstone in New Jersey was less than $7,000, and the output in Connecticut has also greatly declined. The granite industry in Maine and Massachusetts was considered very prosperous then, although its value was only a small fraction of the present value. It is regretted that figures showing quantities of stone produced are not available, as the figures for 1860 were based on conditions just before or during the early stages of an advance in prices whereas the figures for 1917 and 1918 are based on prices existing approximately at the culmination of a period of high prices. Granite quarrying in New Hampshire was still a local industry. Ohio, which in the eighties advanced to the lead in value of stone, chiefly sandstone, was a minor State in 1860. Sandstone from Buena Vista, quarried largely for the Cincinnati market, was then well known, but the famous gray and buff sandstones of Amherst and Berea were only in the early stages of development. Indiana represents a similar but more striking contrast. Its oolitic limestone, though worked for local use from the first decade of the century, was not destined to attain national importance until about 1880.

SINCE THE CIVIL WAR.

SCARCITY OF INFORMATION BEFORE 1880.

There are no data available to show the effect of the Civil War upon the stone industry, and none of much value for showing the size and growth of the industry before 1880. The Ninth Census report gives a total value of $10,775,400 for the output in 1870 from the larger quarries but states that no account was taken of quarries worked irregularly and for local purposes only and admits that many important quarries were undoubtedly overlooked.[3] The value recorded for marble in 1870 was only $804,300, whereas that of granite, sandstone, and limestone together had risen to $9,971,100. The figures may show a substantial increase in total value of the output of the leading quarries compared with the period before the Civil War, but the comparative condition of the industry is obscured by the fact that prices were relatively high in 1870. Wars which took place between 1855 and 1870 had the combined effect of increasing the

[3] Ninth Census, vol. 3, p. 749, 1872.

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public debt, especially in France and the United States. There was a prolonged rise in prices which culminated in 1864 but which persisted at least until 1880. The severe financial panic of 1873 had little effect on checking the high prices.[4]

During the 25 years following the Civil War the stones that were most prominent before the war still led in production. Brownstone, which had found a comparatively very small use in Boston before the war, began in 1865 to supply a great demand, which lasted in that city for about 20 years and, though declining, was important until about 1900. The demand evidently continued to be important in other large eastern cities, although the decline was apparent in New York at an earlier date than in Boston.

The New England granites continued to supply the larger building markets, particularly for heavy masonry, but by 1880 their adaptability for monumental work had become generally appreciated. Marble, chiefly from Vermont, continued to supply the bulk of the monumental trade, however, and was also used for many building fronts, particularly in the seventies. Gray sandstone and limestone continued to be mainly of local importance. The advantage of water transportation and, to a less extent, proximity to large markets appeared still to be dominant factors in the quarry industry.

BUILDING STONE.

1865–1890.—Many of the building stones that were most prominent during the first 20 or 25 years after the Civil War were comparatively dark in color. The brownstones, the Quincy granite, and the darker-red granites of Maine were notable examples, whereas the gray granite of Rockport, Mass., and the lighter-gray granites of Hallowell, Maine, and Concord, N. H., represented the more prominent stones of lighter color. The lighter-pink coarse-grained granites had been regarded with less favor by some because of their texture and because their minerals lacked sufficient contrast in color, especially for monumental work.[5] During the seventies, however, the use of the Indiana oolitic limestone in local important buildings had begun to attract favorable attention. Toward the end of that decade it was used in the construction of the Chicago City Hall and was also introduced into New York. During the next 10 years it was used in the construction of several prominent buildings in New York and doubtless in other important cities in the Central and Middle Atlantic States. By 1890 or 1895 it had been used as far east as Boston, Mass., as far south as Tallahassee, Fla., and as far west as Duluth, Minn; Topeka, Kans.; and El Paso, Tex.[6] A monument base of it had been exported to Caracas, Venezuela.

The ease and cheapness of quarrying and finishing this stone allowed it to compete in spite of long railroad hauls with the more favorably situated and heretofore most prominent building stones, and this all-important fact, together with the relief and contrast which its light-buff and gray colors gave from the more somber

[4] Finlay, J. R., Gold statistics, wars, and prices: Eng. and Min. Jour., p. 347, Aug. 30, 1919.
[5] Merrill, G. P., Stones for building and decoration, p. 61, 1903.
[6] Hopkins, T. C., and Siebenthal, C. E., The Bedford oolitic limestone: Indiana Dept. Geology and Nat. Resources Twenty-first Ann. Rept., pp. 413–427, 1896.

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brownstones and red granites, was a great aid in bringing about a change in fashion favoring light-colored stone for building. This change was also beneficial to the light-buff and gray sandstones of northern Ohio, and to the pale-pink granites, particularly of the Penobscot Bay district, Maine, and Milford, Mass., which gained prominence in 1895–1900, as well as to the already prominent light-gray granites.

During the period from 1865 to 1890 building stone was undoubtedly the leading stone product, although no separate statistics of the value of stone products were compiled until 1898. Monumental and perhaps paving stone were prominent. Crushed stone and limestone for flux were also important products, though insignificant compared with their present prominence, and the Portland cement industry, which had been little more than a curiosity, had just begun to show an increased production in 1890.

Lack of even approximate statistical data renders it impossible to show the effect of business conditions upon the stone industry before 1880. The panic of 1873 doubtless caused a general curtailment of building, and a depression in the building industry is said to have existed from 1876 to 1880.

Approximate annual statistics of production began to be collected in 1880. According to the Tenth Census report, the total value of stone produced in 1880 was about $20,000,000, nearly double the incomplete figure for 1870. (See Pl. IX.) Granite and sandstone produced in 1880 were valued at about $5,000,000; limestone, exclusive of that burned into lime, probably had a similar value, and marble less than half as much. Statistical reports based on very incomplete information were begun by the newly organized United States Geological Survey in 1882. Although building activity increased in 1883, the total value of stone sold was thought to have decreased because of a marked preference for brick construction. To this preference and another general industrial decline was attributed a further decrease in 1884. In 1885 granite and some harder varieties of sandstone increased slightly in favor, whereas the brownstones continued their general decline. In 1886, despite labor troubles, the quantity of stone produced was greater, but prices were lower, owing to such causes as increase in competition, the introduction of new kinds of stone, and efforts to establish markets in new localities. The popularity of granite for ornamental and decorative uses was increasing markedly, the marbles of Tennessee and Georgia had already attained a considerable and growing reputation, and Ohio had become the leading producer of sandstone. During the next three years, or until 1890, the stone industry was generally prosperous, and the period 1886–1890 was the first of two conspicuously prosperous periods for the building-stone industry since annual statistical information has been available.

The apparent great increase in value of stone produced in 1889 over previous years, as recorded by the Tenth Census was evidently the result of a much more complete canvass of the industry and probably to the inclusion of some manufacturing plants with quarries. Several other well-known stones obtained recognition during this period, and so far as quarry districts and range of markets were concerned the stone industry was about as extensive as it is to-day.

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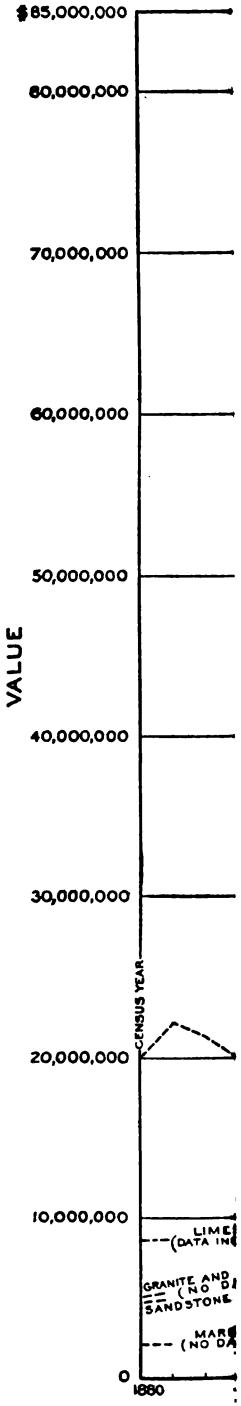

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1891–1918.—This period of prosperity induced overproduction, especially of limestone, and was ended by a decline in the demand for buildings in the larger cities in 1891. Labor troubles in 1891 and 1892 further curtailed production. These dull years were followed by the panic of 1893, when the values of both stone and structural clay products decreased greatly. The value of stone decreased 30 per cent and continued on the whole to decline until 1896 (Pl. IX), whereas the value of structural clay products declined until 1897 (Pl. X). Judged by the length of this period of depression and by the fact that building stone was still by far the leading stone product, the building industry was among the first to suffer and the last to recover. The total value of building stone sold in 1896 was estimated at about $10,000,000.

Portland cement, which had been of almost negligible importance up to 1890, then began to increase rapidly in production, and in 1897 its value exceeded the combined value of marble and bluestone and was about equal to that of all other kinds of sandstone. Its production was not curtailed during the period of depression, and decreasing costs of its manufacture accelerated its marketed production.

The demand for buildings of all kinds had by this time so far exceeded the supply that the value of the building stone, structural clay products, and Portland cement sold increased rapidly until 1903. In that year the value of building stone declined somewhat and was passed by that of Portland cement. In 1904 both building stone and cement decreased in value, while structural clay products held their own. In 1905 and 1906 all three products again increased, but exterior building stone did not quite attain its record value ($20,790,341) of 1902, whereas both clay products and cement far surpassed their previous records. Total building stone, including interior marble, attained its record value, however, in 1906. In 1907 and 1908 a period of depression less severe than that of 1903, the three products again declined, although not uniformly, presumably owing to irregularity in completion of contracts. They all gained in 1909, but the gain in building stone was very small in comparison to those of the others. Since 1909 building stone has almost continuously declined in total value, and the decline has been especially marked since 1912. Structural clay products have fluctuated since 1906 but on the whole declined in value until 1916, and in 1913 they were passed by Portland cement, which has led in value since then. The year 1916 was one of great building activity, as is reflected by the gains in value of structural clay products and Portland cement, but the great majority of the buildings erected were not of the kind that calls for stone.

Since the country entered the World War in 1917 all classes of building have been curtailed and all three materials—building stone, structural clay products, and Portland cement—have decreased markedly in quantity, although the great increase in prices has maintained the respective values at relatively high levels. In spite of increase in selling price, however, the total values of exterior building stones in 1915 and later years are lower than any recorded by the Geological Survey before that date, and it is possible that the values for 1917 and 1918 are the lowest since 1880. It is unfortunate that figures showing the quantity sold annually over a

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long period of years are not available for stone and clay products as they are for cement, because they would show the actual changes in rate of consumption, but fluctations in price have not been, for the most part, sufficiently great to render the accompanying diagrams very misleading, except in respect to 1917 and 1918.

Detailed statistics, 1898–1918.—Plate XI traces the changes in value of granite, marble, limestone, and sandstone sold for building since 1898, the first year in which figures for building stone could be accurately separated from those of other kinds. It was not until 1907, when the period of general decline in total value of building stone began, that any figures for quantity of building stone sold could be published. Figure 110 represents the changes in quantity sold in different districts and groups of districts so far as figures are available.

All kinds of building stone increased in value on the whole from 1898 to 1902, but it is interesting to note that Indiana limestone decreased in value in 1902, when the maximum total value was reached. Granite and marble continued this general increase until 1906, and Indiana limestone also increased in value from 1903 to 1906; but total limestone showed a slight net decline, and sandstone, after gaining in 1903, decreased more than $2,000,000 in the next three years. Since 1906 sandstone and total limestone have undergone general declines in value, although Indiana limestone showed a net gain until 1912. Marble for exterior building fluctuated, but on the whole held its own until 1912. Granite, after a severe decline in 1907, fluctuated, but made a slight net gain until 1913. Since 1914, granite, marble, and sandstone have declined, whereas limestone, three-quarters of whose value was represented by Indiana limestone, gained during 1915 and 1916, after which natural and forced curtailments of building brought a severe decline in the value of all kinds of building stone.

As changes in price during the years preceding 1916 were not abrupt the curves representing values in Plate XI give a fair general idea of the trend of the industry.

Figure 110 shows strikingly the great preponderance in quantity of Indiana limestone sold annually and its marked increase from 1907 to 1912. Its decline since then has been generally paralleled by granite and marble. Building granite in Vermont fluctuated, owing largely to the beginning or completion of large contracts, but on the whole increased from 1907 until 1913, its quantity curve for these years roughly paralleling the corresponding part of the value curve for total granite.

Causes of recent decline.—The period from 1902 to the present has been marked by changes in the building industry that have given Portland cement the advantage over building stone and structural clay products. There was on the whole plenty of building activity, but the trend of architectural style and methods of architectural and engineering construction were powerfully affected by the use of cement and concrete. In the immediate future conditions may closely resemble those that existed after the severe depression between 1890 and 1896. There is a shortage of buildings of all kinds, and there should therefore be a strong demand for all of the three building materials. How long this period of strong demand will last can

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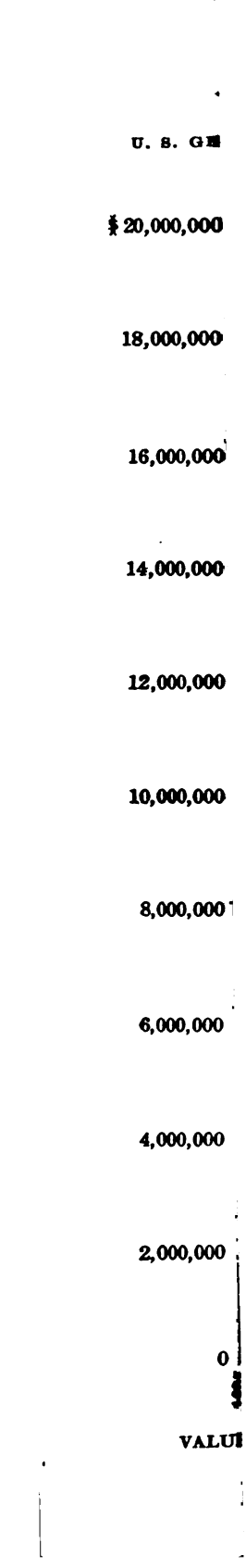

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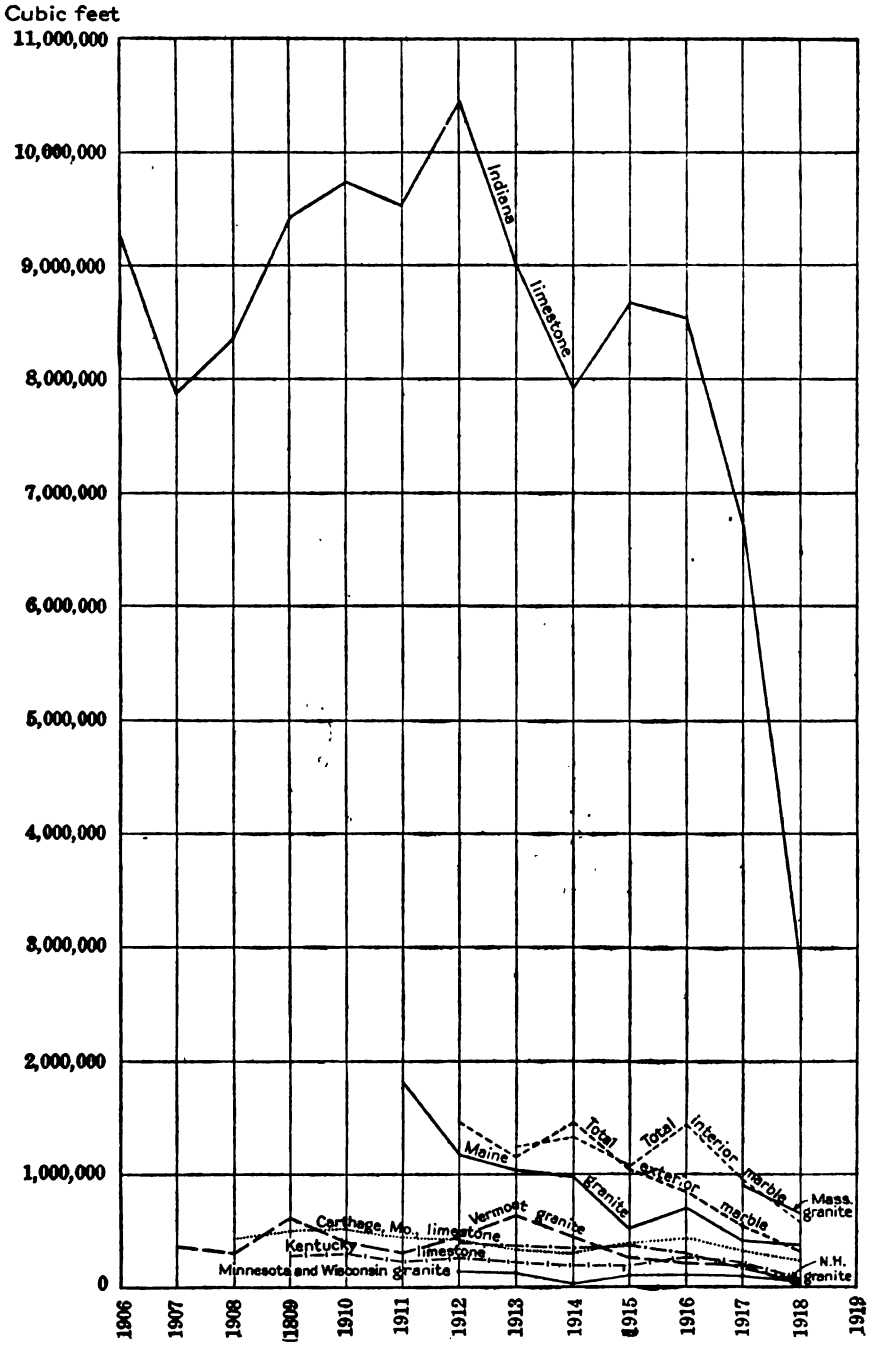

FIGURE 110.—Quantities of certain more important building stones sold in the United States, 1906–1918, by districts.

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not be foretold, and statistics showing the increase in quantity of these products sold during periods of normal growth of the country are too incomplete to indicate how far below normal the consumption of building materials is at present. As regards building stone, there has been a shortage of high-class building since 1913, and this shortage of six years' duration must be compensated while a normal growing demand is being supplied. Informal opinions by men in close touch with the situation forecast a strong demand for the next seven to ten years.

A striking feature of the building-stone industry until the last few years was the lack of cooperation among producers. Because of this, building stone had doubtless suffered more severely from competition with the better-organized cement and clay-products industries than its true qualities and relative cost should have permitted. This was in part remedied by the organization of local and general associations, which had already done considerable to put the building-stone industry on a more modern basis; but their efforts were only begun when war conditions placed all the building industries, organized and unorganized alike, in a most unfortunate position. Now that the demand for buildings of the better classes is due to revive, cooperation on the part of these associations to see that the merits of stone are fairly judged should regain for the stone industry its share of the building construction.

Outlook.—When the demand for war uses caused a shortage in structural steel there was some hope that the building-stone industry would benefit by a return to solid masonry construction. The forced curtailment of building, however, and the short duration of the participation by the United States in the war did not give the required opportunity for such a change in methods of construction to take place. Stone, therefore, is likely to continue to be used mainly for facing and trimming buildings with steel or concrete frames, and its increase in use will depend on its cost of production, its relative merits in competition with other building materials, and the extent to which architectural style in both large and small buildings trends in favor of stone.

STONE FOR OTHER USES.

The growing importance of stone for uses other than building is shown by an examination of the accompanying plates. Comparison of the curves for exterior building stone in Plate XI with curves for total stone in Plate IX brings out the fact that building stone continued to be the principal stone product during both the depressed period of 1892–1896 and the prosperous period of 1897–1902. During most of these years it represented about 40 per cent of the total value of stone sold. Since 1900, however, its proportion of the total value has become less and less. In 1907 it was passed by crushed stone and in 1917 by furnace flux, as shown in Plate XII. The general increase in granite since 1907, as shown in Plate XIII, reflects principally the growing importance of crushed stone, monumental stone, and to a less extent of paving stone; that of limestone (Pl. XV), the growing importance of furnace flux, crushed stone, and stone for chemical and refractory use. Sandstone, a greater portion of which was used for building than for other purposes before the war, most nearly parallels

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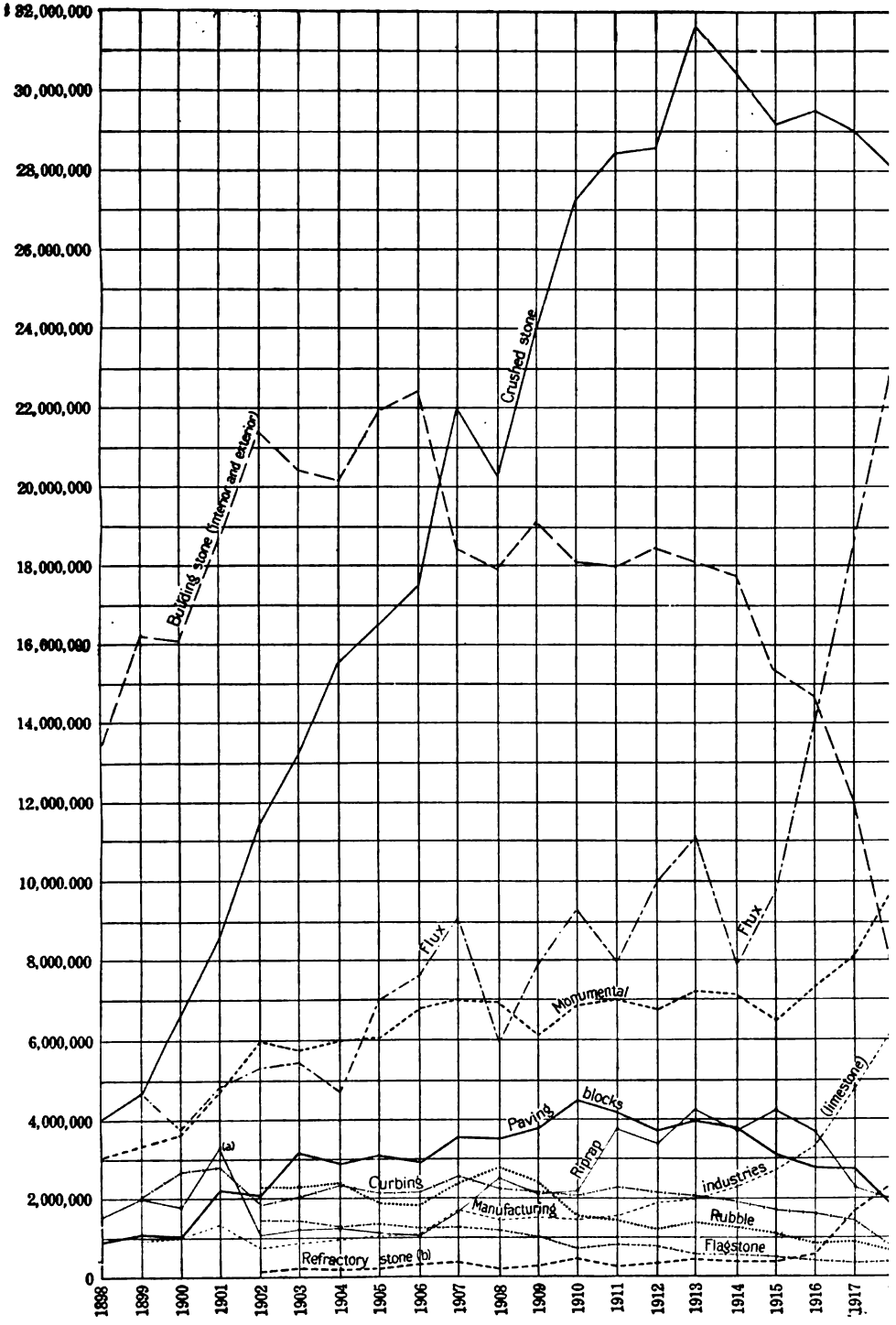

VALUE OF STONE PRODUCTS SOLD IN THE UNITED STATES, 1898-1918, ACCORDING TO USES

(a) Includes rubble; (b) 1902-1916, mica schist and ganister; 1917-1918, mica schist, ganister, and dolomite

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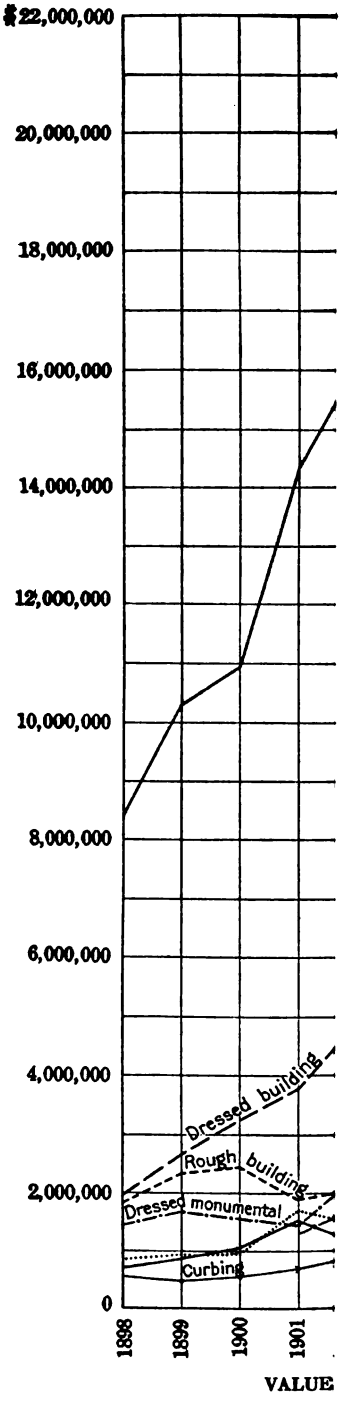

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the declining building-stone curve, and its diversion from this course since 1914 is due to the increasing use of certain varieties of sandstone (principally quartzite) for refractory purposes. Marble has, on the whole, maintained a uniform value, because of its importance in monumental work and in the interior finish of many buildings that contain little or no exterior building stone. The general increase in value of interior marble until 1914 and its minor importance compared with total exterior stone are shown in Plate XI.

The stone industry has thus evolved during the last two decades into a more varied industry than formerly and has been marked by the decline of building stone and certain closely related products and the rise of other products, as shown in Plate XII. This evolution has been gradual and is still in progress, but the transition from the simple to the complex may be said to have taken place between 1890 and 1900. Other uses of stone than building and monumental, though known many years before 1890, did not attract much general attention until then. This statement applies particularly to crushed stone, the use of which had begun prior to 1880, but which was not considered a sufficiently important product to receive more than passing notice. Interpolation from the curves in Plates IX and XII, however, indicates that its total value in 1890 was probably not much in excess of $1,000,000, whereas statistics for 1900 show a value of more than $6,000,000. The earliest definite figures, those for 1898, show a value not much less than that of cement. In the preceding years it was used mainly for road metal, but concrete aggregate and railroad ballast were becoming increasingly important. The steady increase in value of crushed stone until 1914 is in general accord with the nearly steady increase in value of Portland cement, and further illustrates the rapid growth of concrete construction as well as the activity in the improvement of roads. The competition of gravel in concrete and road work has been marked in recent years, but this has been only a minor cause of the gradual decline in value since 1913, which has been due mainly to curtailment first in road and railroad building and, during 1917 and 1918, in concrete building as well.

General parallelism between the crushed-stone curve in Plate XII and the limestone curve since 1898 in Plate IX indicates that limestone has been the principal variety of crushed stone. The excess of the value of limestone over that of total crushed stone, however, is due largely to the value of furnace flux. This product has rapidly increased in importance, keeping pace with the marked growth of the iron and steel and smelting industries, until during the war it became the leading limestone product. The importance of steel in construction work of all kinds, which has increased so markedly since 1896, accounts for the contemporaneous growth in production of flux and to some extent of crushed stone. Decrease in the tenor of iron ore has also tended to increase the quantity of limestone quarried for flux, and the growing demand for limestone very low in harmful impurities has tended to increase the quality as well as the price of stone for this purpose.

Recognition of the importance of limestone in those manufacturing industries using chemical processes has brought about a remarkable increase in the value of stone for various chemical uses in the last few years, as shown in Plate XII. The marked increase in value of

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stone for refractories during recent years also illustrates the growing importance of stone as an accessory to certain manufacturing industries, particularly the steel and by-product coke industries.

Monumental stone has maintained its importance in spite of advances in price, as it is favored by a steady demand little affected by general industrial conditions. During the war it has become the most valuable product of granite and marble quarries, and several companies whose main product has been building stone are now turning their attention to monumental stone.

Paving stone has been for years competing with other paving materials, which had certain advantages over stone as formerly prepared and laid, and has undergone a general decline in value since 1910. There is no question regarding the greater resistance to wear of granite, diabase, basalt, and quartzite paving blocks, and the latest improved methods of preparing and laying them produce smooth road surfaces that will maintain their smoothness so long as the foundation upon which the blocks rest withstands the weight of traffic. As cheaper pavements are proving generally satisfactory for light to rather heavy traffic, the growth of the paving-block industry should keep pace with the growth of extremely heavy city traffic and in the next few years should make up for the curtailment in street improvements during the war.

Riprap and rubble will doubtless continue to fluctuate in production as they have in the past. Where abundant local supplies render them the most economical material for certain structural work they will find temporary use, but they can never be expected to supply more than local demands.

SUMMARY.

The foregoing discussion may be summarized into the brief statement that whereas the stone industry up to about 1900 was chiefly the building-stone industry, with minor values represented mainly by crushed stone, monumental stone, paving, riprap, and rubble, all featuring the stone itself, these products have been in part surpassed in importance by uses in which the stone is an accessory used in the manufacture of different valuable products. In view of the rapid development of manufacturing industries, particularly during the war, there is no occasion to expect a marked change in the present trend of the stone industry. Building stone is expected to increase in use after the abnormally dull war period, but to regain its former position among building materials it must be more thoroughly demonstrated to be not only a superior material but one that can be produced and delivered at a cost low enough to give its superior qualities a broader application, and thus once more to revise prevailing methods of building. Quality at high cost will continue the tendency to restrict building stone to the relatively few elaborate and monumental buildings, whose total annual demand for stone is sufficient to maintain a few well-equipped quarries in profitable existence, without much regard to their geographic location. It is true that the general shortage and expected revival in high-class building may give an impetus to the production of building stone comparable with that of 1897–1902, but the producers who will con-

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tinue after that impetus has spent itself are those who can successfully compete with manufacturers of other building materials.

The more important uses of stone in manufacturing industries have already been mentioned, and minor uses are noted on later pages in sections relating to particular kinds of stone. Few of these minor uses are sufficient alone to keep quarries steadily active, but they may become valuable outlets for by-products of quarries whose main output supplies manufacturing, monumental, or building markets. Producers have already been giving attention to the increasing usefulness of stone in the manufacturing industries, and production for these industries may therefore be expected to show further growth.

PRODUCTION.

GENERAL CONDITIONS IN 1918.

The year 1918, as was to be expected, was a most disastrous one for the stone industry in general. Some of the leading products, notably crushed stone, building stone, and paving stone were regarded as "less essential" to war activities, except for local construction work, and the natural stagnation of construction work was thus intensified by restrictions placed by the War Industries Board upon output, labor supply, and transportation facilities. Several rock products, however, although not hailed as "war minerals," were nevertheless very essential to the successful prosecution of the war. Limestone for flux and various important chemical uses, and dolomite and ganister for refractory use were most noteworthy in this respect, and proposed novel uses of vesicular basalt for lightweight aggregate in concrete ships and of large granite blocks for the walls of acid towers illustrated other special war-time uses of "less essential" materials that bade fair to be realized, had the war continued for a year longer. These war-time uses are considered in the sections devoted to the respective stones.

Crushed stone, although its production was greatly curtailed during the war, must nevertheless be regarded as a war material. One of the first projects carried out by the National Research Council was an investigation of the materials available for rapid road construction in the States along the Atlantic and Gulf coasts. Large quantities of crushed stone were used in construction of roads in the vicinity of cantonments and other military and industrial centers where improvement of roads was of prime importance, but these were far from enough to offset the decrease in use elsewhere, which was intensified by lack of transportation facilities. In contrast to this condition it is stated that in France the demand for crushed stone was so great during the war that to it was given priority in shipment subordinate only to men, food, and munitions. Some of the French quarries supplying crushed stone were equipped with American machinery and operated by American engineers. One of the requests made by the War Department to the United States Geological Survey in 1917 was the preparation of a map showing the available road materials in the territory to be occupied by American troops between Verdun and the Swiss border.

This brief comment on the military uses of stone, though of little satisfaction to the producer whose output was greatly curtailed dur-

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ing the war, has a national significance. It shows that our stone resources, adequate to meet all peace demands, have also proved easily equal to the special requirements of war. They are low-priced commodities and subordinate to such leading commodities as coal, iron, and copper; but they remind us forcibly that abundance, proper distribution, and diversity of both subordinate and primary resources are essential to our industrial independence.

PRODUCTION BY KINDS AND USES.

The total value of the stone sold in the United States in 1918 was $82,700,430, a very slight increase (0.59 per cent) over the value in 1917. This increase followed increases of 4 per cent in 1917 and 6 per cent in 1916, and a decrease of 4 per cent in 1915. The increase in 1918, as in 1917, was due mainly to limestone, whose value increased 6.9 per cent, following an increase of 12 per cent in 1917. and in part to basalt and related rocks, whose value increased nearly 3 per cent. Other kinds of stone decreased in value from 1 to 18 per cent.

Value of the different kinds of stone sold in the United States, 1908–1918.

Year.	Granite.	Basalt and related rocks (trap rock).[a]	Sandstone.	Marble.	Limestone.	Miscellaneous.[b]	Total.
1908	$18,420,080	$4,282,406	$7,594,091	$7,733,920	$27,682,002	.....	$65,712,499
1909	19,581,597	5,133,842	8,010,454	6,548,905	32,070,401	.....	71,345,199
1910	20,541,967	6,452,141	7,930,019	6,992,779	34,603,678	.....	76,520,584
1911	21,194,228	6,739,141	7,730,868	7,546,718	33,897,612	.....	77,108,567
1912	19,223,302	7,560,049	6,893,611	7,786,458	36,729,800	.....	78,193,220
1913	20,733,217	9,134,494	7,248,965	7,870,890	38,745,429	.....	83,732,995
1914	20,160,730	7,865,998	7,501,808	8,121,412	33,894,155	.....	77,544,103
1915	17,864,439	8,489,222	6,095,800	6,916,025	35,229,866	.....	74,595,352
1916	17,456,838	7,666,297	5,603,778	7,033,171	41,309,599	.....	79,069,683
1917	15,544,957	7,570,885	5,512,421	6,330,387	46,263,379	$993,642	82,215,671
1918	14,466,423	7,782,280	4,529,298	5,496,389	49,453,006	973,034	82,700,430
Percentage of increase or decrease in 1918...	−6.9	+2.8	−17.8	−13.2	+6.9	−2.1	+0.59
Percentage of total.....	17.5	9.4	5.5	6.6	59.8	1.2	.....

[a] The term "trap rock" has been variously interpreted and in some localities has been made to include a number of widely different rocks. It is here replaced by the title "basalt and related rocks."

[b] Includes mica schist used for furnace lining, conglomerate, argillite, and various light volcanic rocks used mainly for crushed stone, which can not be properly classified in any of the main groups.

The total quantity sold in 1918 was about 68,563,360 short tons, a decrease of about 18 per cent from the quantity in 1917, which was, in turn, a decrease of about 9 per cent from that in 1916. No stone showed an increase in total quantity sold in 1918, although the sales for a few uses increased in quantity.

Monumental stone increased about 0.5 per cent in quantity and 22.3 per cent in value, passing the record figures for value in 1917. In 1918 nearly 82 per cent of the quantity and 70 per cent of the value of monumental stone was represented by granite, compared with 83 per cent and 70 per cent, respectively, in 1917. The remainder was represented by marble, as the figures do not include negligible quantities of limestone and sandstone. Small quantities of limestone and sandstone sold for monumental use constitute less than 1 per cent of the total quantity and value.

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Stone sold for refractories also increased, owing to the continued rapid growth in the use of dead-burned dolomite, which offset decreases in sales of ganister, sandstone, and mica schist.

Stone for "other uses" was the only other class of stone to increase in quantity in 1918. This included limestone for agricultural purposes and for whiting, both of which increased in quantity and value. Limestone and marble for flux, which increased so markedly in quantity in 1916 and 1917, decreased 6.5 per cent in 1918, keeping pace with the slight retardation of the metallurgical industries; but their value continued to increase, exceeding that of 1917 by $4,833,422, or 25.9 per cent, owing to a rise in average price from $0.73 to $0.98 a long ton. Crushed stone, after a decrease of 16 per cent in quantity and 1.3 per cent in value in 1917, underwent an additional decrease of about 27 per cent in quantity and 4 per cent in value in 1918, and its quantity sold fell below 30,000,000 short tons for the first time since 1906. It still remained the leading stone product, however, exceeding flux by more than 2,580,000 short tons.

Continued depression, caused by war conditions and intensified by restrictions imposed by the War Industries Board, accounts for the decrease in the quantity of stone sold for all other uses. Building stone, after a decrease of 30 per cent in quantity and 17 per cent in value in 1917, underwent an additional decrease of 51 per cent in quantity and 38 per cent in value in 1918, and in all probability fell to the smallest quantity and value sold since 1880, although accurate statistics are not available prior to 1898. Paving blocks decreased nearly 42 per cent in quantity and 37 per cent in value; curbing decreased 59 per cent in quantity and 53 per cent in value; flagging though decreasing 23.5 per cent in quantity made a slight increase (nearly 5 per cent) in value, evidently because work well under way in certain places before restrictions in output were imposed was allowed to proceed.

Stone sold in the United States in 1917 and 1918.

Use.	1917		1918	
	Quantity.	Value.	Quantity.	Value.
Building stone.....cubic feet..	17,467,920	$12,102,914	8,616,000	$7,454,978
Approximate equivalent in short tons.....	1,460,120	.....	719,200	.....
Monumental stone.....cubic feet..	4,058,626	8,102,493	4,072,343	9,912,167
Approximate equivalent in short tons.....	341,420	.....	343,100	.....
Paving blocks.....number..	48,907,670	2,732,434	28,516,910	1,714,011
Approximate equivalent in short tons.....	511,060	.....	298,650	.....
Curbing.....cubic feet..	a 2,367,163	1,402,980	951,650	661,188
Approximate equivalent in short tons.....	196,900	.....	80,570	.....
Flagging.....cubic feet..	a 1,043,738	356,327	798,934	373,729
Approximate equivalent in short tons.....	a 86,390	.....	65,900	.....
Rubble.....short tons..	915,646	864,321	482,365	635,895
Riprap.....do....	2,933,877	2,208,373	2,273,852	1,923,154
Crushed stone.....do....	40,285,377	29,065,899	29,373,342	27,951,393
Furnace flux b.....long tons..	25,574,146	18,679,213	23,917,040	23,512,635
Equivalent in short tons.....	28,641,044	.....	26,787,085	.....
Refractory stone c.....short tons.	1,573,573	1,607,743	1,825,183	2,363,154
Manufacturing industries b.....do....	5,446,558	4,070,351	4,838,108	4,194,013
Other uses.....do....	1,175,079	1,023,013	1,476,905	2,004,118
Total (quantities, approximate in short tons)..	a 83,574,900	82,215,671	68,563,360	82,700,430

a Revised.
b Limestone alone in 1917; limestone and marble in 1918.
c Ganister, mica schist, and dolomite.

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This is the second report in which a full statement of the total quantity as well as the total value of the stone sold is given. The figures of quantity are particularly timely in showing the actual change in volume of the industry, which is not reflected by figures of value, owing to the great and rapid advances in price. On account both of the different units of quantity reported by different producers and of the different measurements used for the various products the accurate conversion of all of them to one unit (the short ton) has presented difficulties and has necessitated estimates based on the specific gravity of the various stones. Estimates were necessary also on less than 5 per cent of the total value of the entire output, for which no quantities were given by the producers, but data for estimates in this report are more complete and accurate than those used in the report for 1917. The figures for 1917 have been revised accordingly.

The figures in this as in previous reports represent stone produced and sold or used by the quarrymen. They include only such manufactured products as are put on the market by the quarrymen themselves—some building and monumental stone, crushed stone, flagstone, curbstone, and paving blocks. The value given to these manufactured products is that received by the producer free on board at point of shipment. The value given for the rough stone sold to local trade is, so far as ascertainable, that of the stone at the quarry, but occasionally, if the producer also delivers the stone, includes the cost of delivery. In a few places, where the producer has a long haul to market or to a railroad shipping point, this cost materially increases the selling price.

As in the report for 1917 the kinds of stone represented in this report are classified as granite, basalt and related rocks (trap rock), marble, limestone, sandstone, and "miscellaneous."

"Granite" includes true granite and also such allied rocks as monzonite, syenite, and gneiss. From time to time small quantities of dark igneous rocks, such as diorite and gabbro, used for monumental and building work are also included with granite.

"Basalt and related rocks," included under the term "trap rock" until 1914, comprise, besides typical basalt and diabase, fine-grained diorite, gabbro, and other basic rocks which are less common in occurrence but are similar in chemical and physical properties and are used largely as crushed stone.

"Marble" includes a small quantity of serpentine quarried and sold as marble in California, Georgia, Maryland, Massachusetts, Pennsylvania, and Vermont, and also (when produced) a small quantity of the so-called onyx marble or travertine obtained from caves and other deposits in Kentucky and other States.

The "limestone" represented in the tables of this report does not include limestone burned into lime, bituminous limestone, nor limestone entering into the manufacture of Portland cement. Separate reports are made on the lime, asphalt, and cement industries.

"Sandstone" includes the quartzites of South Dakota, Minnesota, and Wisconsin, and the fine-grained sandstones of New York and Pennsylvania, known to the trade as "bluestone." As "bluestone" is the product of a distinct local industry its production is shown separately from that of the other sandstones. "Bluestone" is also quarried in New Jersey and West Virginia, but this output is small

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and is not separated from sandstone. In Kentucky most of the sandstone quarried and sold is known locally as freestone. The figures given for sandstone do not include the value of the grindstones, whetstones, and pulpstones made from sandstones quarried in Arkansas, Indiana, Michigan, Ohio, and West Virginia. These products are included in the report on abrasives. Sandstone crushed into sand and used in the manufacture of glass and as molding sand is considered in the report on sand and gravel.

"Miscellaneous" includes light-colored volcanic rocks, including tuff, rhyolite, trachyte, andesite, and some mica schist, which have previously been classed with granite or basalt; flint rock, previously classed with limestone; conglomerate, argillite, and mica schist used for furnace lining, previously classed with sandstone. The separation may not be complete for 1918, but it is hoped to make the classification better as more knowledge is obtained of the character of the stone for which statistical reports are made.

PRODUCTION BY STATES.

In 1918, as in 1917, production was reported from 50 States and Territories. Pennsylvania, Ohio, and Vermont in 1918 continued to be the three ranking States in value of stone produced. New York, which was fourth in 1917, was passed by Michigan, which advanced from sixth to fourth place. Indiana, which ranked fifth in 1917, dropped to eighth place. Of the 46 States whose individual production is shown on page 1207, 19 increased and 27 decreased in the value of their output. In the region east of Mississippi River 12 showed increase and 13 decrease; in the region to the west 7 showed increase and 14 decrease. As would be expected from the figures of production by uses, most of the important States (Pennsylvania, Ohio, Michigan, West Virginia, Alabama, and Virginia) with increased value of output are States which supply large quantities of limestone to metallurgical and manufacturing plants; the same is true of less important States with increased value, most of which are west of Mississippi River. Exceptions to this rule are New Jersey, with increased output of furnace flux and limestone for agricultural use; Georgia, with increased production of limestone for agricultural and industrial uses; New Hampshire, with increase in both quantity and value of monumental granite sold; South Carolina, with increase in crushed granite sold; and Rhode Island, with increase in granite for monuments and building. Of the States showing decreased value Indiana, whose principal output is limestone for building, was the most severely affected, its value decreasing 37 per cent. The other prominent States with decreased value produced mainly building and crushed stone.

The number of plants reporting operations continued to decrease, from 2,647 in 1917 to 2,118 in 1918. In only six States of comparatively small production, Washington, Wyoming, New Mexico, Idaho, Mississippi, and the District of Columbia, did the number of producers increase. The abnormal conditions doubtless hastened the reduction in number of producers. Some small quarries were closed on account of the enlistment or draft of the owner or operator. In several States quarries were taken over by the United States Government

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early in 1918, and held until after the signing of the armistice. From very few of these has it been possible to get the record of output while under Government control, as the quarries were held so short a time that records of operations had not become systematically kept. The expected strong demand for structural stone with return to normal conditions may tend to encourage small operators to resume business, but unless this demand is accompanied by a considerable decrease in cost of operation it is not likely that the number of operators will be materially increased. The present stage in the evolution of the stone industry involves diminution in the number of operators, only those with adequate capital and equipment continuing in business.

Value of stone sold in the United States, 1917 and 1918, by States.

1917.

Rank of State.	State.	Total value.	Percentage of total.	Number of plants.
1	Pennsylvania	$14,048,158	17.09	459
2	Ohio	6,486,605	7.89	162
3	Vermont	5,920,799	7.20	48
4	New York	5,399,403	6.57	156
5	Indiana	4,449,809	5.41	93
6	Michigan	3,423,825	4.16	35
7	Illinois	3,322,041	4.04	82
8	Massachusetts	3,113,423	3.79	107
9	California	2,911,462	3.54	104
10	Wisconsin	2,787,023	3.39	147
11	Missouri	1,983,300	2.41	137
12	North Carolina	1,896,554	2.31	47
13	New Jersey	1,860,397	2.26	72
14	West Virginia	1,841,071	2.24	51
15	Georgia	1,797,098	2.19	35
16	Minnesota	1,711,318	2.08	66
17	Tennessee	1,635,573	1.99	69
18	Virginia	1,612,118	1.96	68
19	Alabama	1,611,497	1.96	29
20	Maine	1,254,637	1.53	40
21	Connecticut	1,238,684	1.51	46
22	Kentucky	1,118,434	1.36	90
23	Maryland	938,637	1.14	42
24	New Hampshire	921,943	1.12	23
25	Colorado	823,904	1.00	47
26	Texas	697,540	.85	28
27	Kansas	673,831	.82	57
28	Florida	654,845	.80	16
29	Oklahoma	625,048	.76	28
30	Iowa	520,083	.63	45
31	Rhode Island	518,785	.63	16
32	Hawaii	483,453	.59	7
33	Nebraska	476,307	.58	15
34	Washington	454,594	.55	26
35	South Carolina	427,531	.52	15
36	Oregon	413,867	.50	27
37	Arkansas	371,732	.45	15
38	Arizona	319,724	.39	15
39	Utah	305,968	.37	17
40	Montana	255,835	.31	15
41	Delaware	216,346	.26	5
42	South Dakota	182,907	.22	15
43	Wyoming	156,180	.19	9
44	Idaho	94,644	.12	6
45	Alaska	(a)	.....	1
46	New Mexico	72,411	.09	5
47	Louisiana	(a)	.....	1
48	Nevada	31,625	.04	3
49	District of Columbia	4,615	.01	4
50	Mississippi	(a)	.....	1
	Undistributed	150,087	.18	.....
		82,215,671	100.00	2 647

a Included in "Undistributed."

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Value of stone sold in the United States, 1917 and 1918, by States—Continued.

1918.

Rank of State.	State.	Total value.	Percentage of total.	Number of plants.
1	Pennsylvania	$15,783,147	19.08	364
2	Ohio	7,917,740	9.57	128
3	Vermont	5,505,895	6.66	40
4	Michigan	5,264,432	6.37	34
5	New York	5,208,752	6.30	123
6	Massachusetts	3,069,461	3.71	82
7	Illinois	2,990,150	3.62	54
8	Indiana	2,819,083	3.41	69
9	California	2,564,614	3.10	91
10	Wisconsin	2,392,456	2.89	123
11	New Jersey	2,210,407	2.67	54
12	West Virginia	2,024,525	2.45	40
13	Georgia	1,903,255	2.30	31
14	Minnesota	1,710,267	2.07	50
15	Alabama	1,669,721	2.02	23
16	Missouri	1,668,789	2.02	112
17	Virginia	1,638,077	1.98	62
18	North Carolina	1,581,381	1.91	30
19	Tennessee	1,493,858	1.81	51
20	Maine	1,212,643	1.47	36
21	Connecticut	1,025,475	1.24	32
22	New Hampshire	1,013,526	1.23	19
23	Kentucky	970,494	1.17	64
24	Maryland	921,199	1.11	35
25	Colorado	771,472	.93	38
26	Oklahoma	696,195	.84	23
27	Texas	647,287	.78	26
28	South Carolina	599,984	.73	9
29	Rhode Island	577,494	.70	13
30	Kansas	561,382	.68	46
31	Arkansas	481,998	.58	13
32	Hawaii	467,145	.56	5
33	Iowa	379,029	.46	38
34	Washington	365,098	.44	30
35	Utah	355,579	.43	13
36	Nebraska	315,200	.38	13
37	Florida	304,807	.37	10
38	Montana	282,228	.34	15
39	Arizona	278,127	.34	10
40	Oregon	233,521	.28	18
41	Wyoming	182,087	.22	11
42	Delaware	(a)	.....	2
43	South Dakota	97,894	.12	12
44	Nevada	95,821	.12	3
45	New Mexico	80,343	.10	6
46	Louisiana	(a)	.....	1
47	Alaska	(a)	.....	1
48	Idaho	68,367	.08	8
49	District of Columbia	7,585	.01	5
50	Mississippi	(a)	.....	2
	Undistributed	286,460	.35	.....
		82,700,430	100.06	2,118

a Included in "Undistributed."

EXPORTS.

The following tables of exports were compiled by J. A. Dorsey from the records of the Bureau of Foreign and Domestic Commerce, Department of Commerce.

Stone exported from the United States, 1913–1918.

Kind.	1913	1914	1915	1916	1917	1918
Marble and stone, unmanufactured	$606,745	$559,556	$400,510	$403,303	$572,097	$552,261
All others, manufactured	1,250,147	803,686	635,614	1,077,447	1,108,185	1,208,164
	1,856,892	1,363,242	1,036,124	1,480,750	1,680,282	1,760,425

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After a decline during 1914 and 1915, there has been a steady increase in total value of exports during the last three years, and the value for 1918 is only $96,467, or 5 per cent, less than that of 1913, the latest normal year. The advance in 1918 was made by manufactured stone. The unmanufactured stone, including marble, underwent a small decrease.

Stone (including marble) exported from the United States in 1917 and 1918.

Country.	Manufactured.	Unmanufactured.	Country.	Manufactured.	Unmanufactured.
1917.			**1918.**		
Europe:			Europe:		
Denmark	$4,779	.....	France	$18,787	.....
France	46,539	$231	Great Britain	77,461	.....
Great Britain	111,387	1,181	Iceland and Faroe Islands	1,591	.....
Greece	250	.....	Italy	7,997	.....
Italy	13,314	.....	Norway	2,062	.....
Netherlands	584	.....	Portugal	2,086	.....
Russia in Europe	3,271	.....	Spain	28,598	.....
Sweden	2,161	.....	Switzerland	6,120	.....
Other Europe	46,412	.....			
	228,697	1,412		144,702	.....
North America:			North America:		
Canada	405,433	524,001	Canada	564,115	$477,985
Newfoundland, Labrador, etc	7,175	2,157	Newfoundland	10,354	1,200
Mexico	29,417	29,463	Mexico	27,400	5,575
Central America	8,479	240	Central America	6,362	1,453
Panama	30,869	2,168	Panama	18,695	115
Cuba	66,718	6,092	Cuba	101,581	59,313
Jamaica	5,874	.....	Jamaica	9,303	5,545
Other British West Indies	10,692	64	Bermuda	382	21
French West Indies	561	.....	Other British West Indies	6,331	57
Other West Indies	8,254	244	Dutch West Indies	1,619	.....
			French West Indies	370	.....
			Virgin Islands	689	.....
			Haiti	2,305	.....
			Dominican Republic	3,664	51
	573,472	564,429		753,170	551,315
South America:			South America:		
Argentina	41,877	.....	Argentina	17,268	.....
Brazil	31,402	124	Brazil	23,261	.....
Chile	29,388	803	Chile	94,213	.....
Colombia	12,218	.....	Colombia	8,766	706
Peru	9,677	4,494	Ecuador	5,356	.....
Uruguay	1,358	6	Peru	6,017	.....
Venezuela	4,703	30	Venezuela	3,025	.....
Other South America	10,191	.....	Other South America	3,562	10
	140,814	5,457		161,488	716
Asia:			Asia:		
China	8,867	25	China	10,769	28
British India	21,570	.....	British India	7,035	.....
Dutch East Indies	43,949	30	Dutch East Indies	36,679	5
Japan	9,852	701	Japan	27,500	.....
Other Asia	8,987	.....	Other Asia	2,521	17
	93,225	756		84,504	50
Oceania:			Oceania:		
Australia	31,640	.....	Australia	24,365	.....
New Zealand	11,010	.....	New Zealand	10,698	.....
Philippines	1,769	30	Philippines	5,284	180
Other Oceania	595	13	Other Oceania	1,397	.....
	45,014	43		41,744	180
Africa:			Africa:		
British South Africa	25,106	.....	British South Africa	20,694	.....
Other Africa	1,857	.....	Other Africa	1,862	.....
	26,963	.....		22,556	.....
Total exports	1,108,185	572,097	Total exports	1,208,164	552,261
Grand total	1,680,282		Grand total	1,760,425	

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To the North American countries as usual is credited the greater part of the shipments of stone as indicated by their value. These countries received 74 per cent of the total in 1918. This is an increase of 6 per cent over 1917 and of about 17 per cent over 1916 and indicates a tendency to return to the more nearly normal figure of 83 per cent, represented by the year 1914. These changes are shown

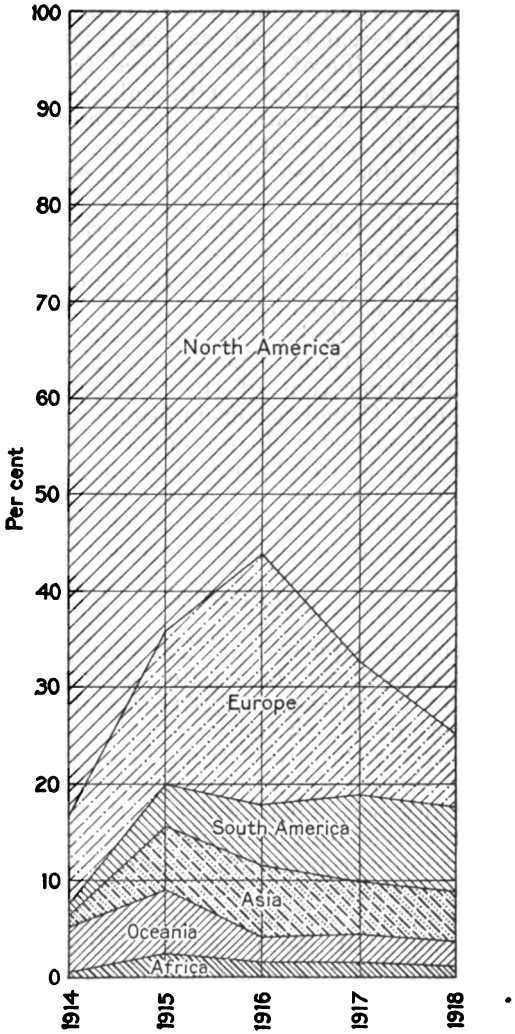

FIGURE 111.—Percentages of stone, by value, exported to different continents, 1914–1918.

graphically in figure 111. The sharp decline in 1915 in value of shipments to North American countries and the increase to European countries and in a lesser degree to all other countries, was followed in 1916 by a further large increase in value of shipments to Europe and all countries except North America. In 1917 the restrictions on shipments to Europe except for essentials caused the figures for that

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country to decline sharply with considerable increase for North America and less increase for South America, and decrease for Asiatic countries. In 1918 the decrease to Europe continued, as did the increase to North America and South America. Asia also decreased. The shipments to Oceania and Africa remained in about the same proportion for 1916, 1917, and 1918.

Of the European countries, France, Great Britain, and Italy received shipments of largest value in 1916, 1917, and 1918. In 1918, however, France and Great Britain decreased 60 per cent and 31 per cent, respectively, in value of stone received from this country, and Italy fell off nearly 40 per cent. Although the value of shipments to Asia, Oceania, and Africa decreased somewhat, there was an increase of $16,947 (161 per cent) in the shipments to Japan. There was also increased value of shipments to China and the Philippine Islands.

The value of the shipments of stone to North America and South America, however, showed increase of 31 per cent and 15 per cent, respectively, in manufactured product, the unmanufactured material showing decrease for each continent and for almost every country. The stone shipped to Canada, the largest customer for the United States, constituted more than 59 per cent of the total value of shipments and about 80 per cent of the value represented by North American shipments. Canada's consumption is about equally divided in value between manufactured and unmanufactured material. In 1918 there was an increase of 39 per cent in the value of manufactured stone received and a decrease of nearly 9 per cent in rough stone. The increase in South America was in the value of shipments to Chile, all the other countries showing decrease.

IMPORTS.

The term "general imports" in this publication embraces both imported articles entered for immediate consumption on arrival and articles entered for warehouse, as distinguished from the term "imports for consumption," which embraces imports entered for immediate consumption and withdrawals from warehouse for consumption. The statement of general imports and the statement of imports for consumption for any period will differ to the extent that the value of the entries for warehouse for the period differs from the value of the withdrawals from warehouse for consumption. The term "entry for consumption" is the technical name of the import entry made at the customhouse and does not imply that the goods have been actually consumed, but simply that they have been delivered into the custody of the importer and that the duties have been paid on the dutiable portion.

The stone imported for consumption in the United States in 1918 was valued at $268,577, which was $412,898, or 61 per cent, less than in 1917, which in turn was 29 per cent less than in 1916. The imports of marble, including the usual small imports of "onyx marble," amounted to $235,430, or 88 per cent, of the total stone imported for consumption, a decrease of $345,992, or 60 per cent, compared with 1917, which was 20 per cent less than 1916.

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Stone imported for consumption in the United States in 1916, 1917, and 1918.

Kind.	1916		1917		1918	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Marble:						
In blocks, rough, etc.....cubic feet..	350,941	$529,125	267,250	$428,396	96,478	$192,641
Sawed.....do....	51	246	9	25	.....	.....
Slabs or paving tiles.....square feet..	70,545	15,221	124,935	27,884	26,118	5,304
All other manufactures.....	.....	122,145	.....	87,177	.....	28,798
Mosaic cubes:						
Loose.....	.....	22,285	.....	13,434	.....	5,508
	.....	689,022	.....	556,916	.....	232,251
Onyx:						
In blocks, rough, etc.....cubic feet..	9,071	32,282	6,935	22,439	1,398	3,046
Slabs or paving tiles.....square feet..	.....	.....	5,976	1,595	.....	.....
All other manufactures.....	.....	2,077	.....	472	.....	133
	.....	34,359	.....	24,506	.....	3,179
Granite:						
Dressed.....	.....	66,331	.....	25,119	.....	1,328
Rough.....cubic feet..	23,773	9,366	18,982	9,923	18,473	9,653
	.....	75,697	.....	35,042	.....	10,981
Stone (other):						
Dressed.....	.....	11,456	.....	15,296	.....	5,060
Rough (monumental or building stone), cubic feet.....	95,005	66,337	53,537	40,330	11,995	12,716
Rough (other).....	.....	82,496	.....	9,385	.....	4,390
	.....	160,289	.....	65,011	.....	22,166
Grand total.....	.....	959,367	.....	681,475	.....	268,577

The only figures available showing the source of imported stone are those for marble, which are given in the following tables. The information for 1918 includes a partial statement for quantity, the first time these figures have been obtained.

General imports of marble and onyx, rough and manufactured, into the United States in 1916 and 1917.

1916.		1917.	
Belgium.....	$99	France.....	$18,952
France.....	32,069	Gibraltar.....	49
Greece.....	9,688	Italy.....	516,239
Italy.....	640,905	Spain.....	208
Great Britain.....	11,870	England.....	22,493
Denmark.....	4,179	Ireland.....	73
Spain.....	598		
Total Europe.....	699,308	Total Europe.....	558,014
Canada.....	891	Canada.....	314
Mexico.....	35,657	Mexico.....	3,257
Cuba.....	216	Cuba.....	1,917
Guatemala.....	2		
Total North America.....	36,766	Total North America.....	5,488
Other countries.....	1,614	Other countries [a].....	4,338
Grand total.....	737,688	Grand total.....	567,840

[a] Includes China, Japan, Hongkong, Philippine Islands, and Colombia.

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General imports of marble and onyx, rough and manufactured, into the United States in 1918.

Country.	Marble and breccia.[a]	Marble, breccia, and onyx.[b]		Manufactured.	Total value.
	Value.	Quantity (cubic feet).	Value.	Value.	
France	$1,690	123	$286	$652	$2,628
Germany				8	8
Italy	187,139	32,657	64,018	6,529	257,686
Portugal	125				125
Spain	56			61	117
England	2,008			1,252	3,260
Total Europe	191,018	32,780	64,304	8,502	263,824
Canada	850	423	2,216	25	3,091
Mexico	133			95	228
Total North America	983	423	2,216	120	3,319
Japan	885			175	1,060
Other countries[c]	87			176	263
	972			351	1,323
Grand total	192,973	33,203	66,520	8,973	268,466

[a] Figures for January to June, inclusive.
[b] Figures for July to December, inclusive.
[c] Includes Barbados, Trinidad and Tobago, China, British India, Hongkong, and Australia.

Almost the entire value of general imports represents marble imported from Italy, England, and France, nearly 96 per cent coming from Italy alone. That credited to England may include Grecian marble reexported. Imports from Mexico, whose value decreased from $35,657 to $3,257 in 1917, amounted to only $228 in 1918. Onyx marble imported for consumption in 1918 amounted to $3,179. As the greater part of this is believed to have come from Mexico the difference in value indicates that in 1918, as in 1917, a much greater quantity was taken from warehouses than was brought into the country. The value of marble imported from or through Canada in 1918 was nearly ten times that in 1917 and more than three times that in 1916.

Monthly returns from January to April and July to August, 1918, show that only a little more than half of the total value of marble and onyx imported from Europe and Canada was represented by stone received prior to the signing of the armistice, whereas most of that from Asiatic and other ports was received during that period. Receipts from France and England were almost nil between March and September, the period of most intense submarine activity and of partial embargoes on "less essential" commodities. Those from Italy, low in January and February, doubled in both March and April, and then declined to comparative insignificance until November. Most of the imports, including shipments from many if not all the countries of origin, were entered at New York. Philadelphia received some shipments from Italy, France, and Japan; Chicago and St. Louis shipments from Italy; San Antonio, Tex., shipments from Mexico; San Francisco, shipments from Japan and Italy; and Hawaii, a shipment from Australia. A small part of the marble

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from England was entered at some port in Ohio, and at least one shipment from Canada was entered in Vermont.

The expected revival of commercial enterprises and the consequent attention being given to tariff regulations have led some of the manufacturers and dealers of the United States to start a movement with the United States Tariff Commission looking to the increasing of the tariff on all finished marble work now brought into this country free of duty. At present there is a duty of 50 cents per cubic foot on the rough quarried marble, 75 cents on sawed or dressed marble, 6 to 12 cents on slabs or tiles, according to their thickness and rubbed or unrubbed surfaces, 45 per cent ad valorem on all other manufactured marble, and 20 per cent ad valorem on loose mosaic cubes.

The value of granite imported for consumption continued to decrease, owing to the almost complete cessation of imports of dressed stone, whereas the quantity and value of rough granite remained about stationary. The almost stationary price of this rough granite (about 52 cents a cubic foot in both 1917 and 1918) is in keeping with the small decline in average price of domestic rough granite, which was due to a large output of low-priced stone in eastern Pennsylvania. No specific data regarding countries of origin are available, but it is presumed that most of the granite imported came originally from the Scandinavian peninsula.

The value of imported stone other than marble, after decreasing nearly 60 per cent in 1917 decreased 66 per cent more in 1918, rough and dressed stone decreasing in about equal proportion. Data regarding countries of origin are incomplete, but are sufficient to show that more than half the total value in 1918 represents stone from France. Stone from England was valued at more than $3,000, stone from Scotland less than $3,000, and stone from Canada less than $2,000. Small shipments came from Mexico and Japan, and insignificant quantities from Hongkong, China, and Brazil. Probably all the French stone and most of the English and Scotch stone was entered at New York. A small quantity of English stone was received at ports in Massachusetts and Rhode Island. Much, if not all, of the Canadian stone was entered at Buffalo, N. Y., and ports in Michigan. Most of the Japanese stone was entered at Hawaii, San Francisco, and ports in Oregon and Washington, an insignificant quantity being received at New York.

Most of the "other" stone imported from Europe was received during or before March, when the embargo was placed on imports of monumental and building stone. Shipments from France and Scotland, however, were received during August and later months, presumably as return cargoes which could be loaded without delay to shipping of essential war material. The embargo continued until May 22, 1919.

GRANITE.

GENERAL STATISTICS.

The granite sold in the United States in 1918 amounted to 3,827,400 short tons, valued at $14,466,423, about 5.6 per cent of the quantity and 17.5 per cent of the value of the entire output of stone for the year, compared with 7 per cent and 19 per cent, respectively, in 1917.

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The figures for granite in 1918 showed a decrease of 31 per cent in quantity and 7 per cent in value from those for 1917, which in turn were 40 per cent and 11 per cent less than those of 1916, and were the lowest recorded for value since 1901. The adverse conditions of 1916 and 1917 were intensified by concentration of industrial activity on the winning of the war.

In 1918, as in 1917, granite was sold in 30 States, including the District of Columbia. Of the 25 States, the value of whose output is given in the table below, 11 showed increase and 14 decrease. The States with increased value include Minnesota, Montana, New Hampshire, and Rhode Island, whose principal output is monumental stone, although building stone was also important in New Hampshire and Rhode Island; New York, whose leading products were paving and crushed stone; Pennsylvania, whose rough building stone represented about one-half the value; Virginia and South Carolina, whose outputs were largely crushed stone; Oklahoma, Washington, and the District of Columbia, whose output values are not itemized. As shown in the review by States, those States whose outputs of building, paving, and crushed stone increased were favored by war contracts. The large apparent decrease in the granite figures for Maryland was due somewhat to the transference of a quantity of stone more nearly allied to the basaltic rocks to the section of this report dealing with basalt.

Value of granite sold in the United States, 1914–1918.

State.	1914	1915	1916	1917	1918
Arizona	$37,831	$71,087	$203,702	$135,080	$76,287
Arkansas		(a)			
California	2,386,579	1,656,706	1,433,022	844,453	838,786
Colorado	74,774	65,876	78,823	113,800	112,461
Connecticut	405,655	318,909	270,740	212,665	148,317
Delaware	131,086	131,379	121,354	216,346	(a)
District of Columbia		5,775	3,315	4,615	7,585
Georgia	958,831	660,454	813,068	568,143	558,296
Idaho	(a)	(a)			
Maine	1,717,110	1,062,283	1,068,485	1,254,529	1,211,743
Maryland	846,838	662,466	633,218	603,062	180,189
Massachusetts	2,091,417	2,071,203	1,997,150	1,932,511	1,805,396
Minnesota	735,753	841,943	1,048,816	1,102,493	1,167,878
Missouri	77,971	85,625	80,390	58,241	54,523
Montana	25,977	28,829	18,175	25,831	28,894
New Hampshire	1,383,325	1,234,149	1,141,810	909,700	1,003,328
New Jersey	74,808	95,986	71,421	47,372	31,500
New Mexico	(a)		(a)	(a)	(a)
New York	797,297	747,242	368,119	182,515	191,551
North Carolina	1,286,345	1,246,810	1,798,087	1,486,541	1,155,626
Oklahoma	24,695	29,141	80,597	37,071	116,231
Oregon	36,852	7,246	17,080	(a)	(a)
Pennsylvania	511,013	506,360	446,868	290,748	310,050
Rhode Island	621,620	691,765	631,237	477,779	525,052
South Carolina	357,657	319,080	447,570	427,531	599,864
South Dakota	(a)	22,379	(a)	(a)	(a)
Texas	115,857	86,968	84,379	95,867	46,297
Utah	(a)	(a)	(a)	(a)	(a)
Vermont	3,120,452	2,778,730	2,598,835	2,850,615	2,689,652
Virginia	805,287	869,384	451,697	307,224	336,696
Washington	72,079	260,688	90,525	52,053	65,293
Wisconsin	1,341,455	1,256,851	1,390,968	1,248,112	962,869
Undistributed	122,166	49,175	67,387	60,060	242,054
	20,160,730	17,864,439	17,456,838	15,544,957	14,466,423

a Included in "Undistributed."

In the following table, which summarizes the production of granite by uses, quantities are expressed in the usual units. They

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are given, also, approximately in short tons in order to express the total quantity.

Granite sold in the United States in 1917 and 1918.

Use.	1917		1918	
	Quantity.	Value.	Quantity.	Value.
Building stone (rough and dressed).....cubic feet..	3,604,330	$3,161,294	2,771,013	$2,349,796
Approximate equivalent in short tons.....	302,800	.....	232,770	.....
Monumental stone.....cubic feet.	3,373,068	5,704,776	3,358,431	6,964,879
Approximate equivalent in short tons.....	282,800	.....	282,000	.....
Paving.....number of blocks..	40,224,951	2,319,598	25,923,526	1,547,612
Approximate equivalent in short tons.....	422,400	.....	272,200	.....
Curbing and flagging.....cubic feet..	927,380	699,444	382,000	324,381
Approximate equivalent in short tons.....	77,900	.....	33,600	.....
Rubble.....short tons	164,712	199,766	140,472	151,408
Riprap.....do....	1,018,452	583,409	624,954	480,666
Crushed stone.....do....	3,065,126	2,700,620	2,069,473	2,583,449
Other stone.....do....	[a] 230,000	176,059	171,944	64,232
Total (quantities approximate, in short tons).	[a] 5,564,200	15,544,957	3,827,400	14,466,423

[a] Estimated in part.

Crushed stone constitutes by far the greatest part of the quantity, 55 per cent in 1917 and 54 per cent in 1918, and is the only product exceeding 1,000,000 short tons. Riprap, which exceeded that figure in 1917, decreased nearly 39 per cent in 1918. Building stone, which amounted to about 6 per cent in 1916 and 5 per cent in 1917, rose again to 6 per cent in 1918, in spite of its continued marked decrease in actual tonnage. Monumental stone, in spite of decrease in actual tonnage, has risen from 3 per cent in 1916 to 5 per cent in 1917 and to 7 per cent in 1918, exceeding both building stone and paving in quantity. Paving stone also, in spite of decline in actual quantity, rose from 5 per cent in 1916 to about 7 per cent in both 1917 and 1918. In value, however, monumental continued to gain and in 1918 constituted nearly half (48 per cent) the total value of granite sold. Building stone, which had been ranking second in value, was passed by crushed stone in 1918. The values of the different granite products sold since 1898 are shown graphically in Plate XIII.

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Granite sold in the United States in 1917, by States and uses.

State.	Building.				Monumental.			
	Rough.		Dressed.		Rough.		Dressed.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Cubic ft.		*Cubic ft.*		*Cubic ft.*		*Cubic ft.*	
Arizona	(a)	(a)			(a)	(a)	(a)	(a)
California	11,464	$8,253	57,140	$201,454	36,693	$34,475	15,788	$64,902
Colorado	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Connecticut	92,376	20,789	11,353	23,546	43,234	52,816	11,965	61,970
Delaware	99,002	12,957	(a)	(a)				
Dist. of Columbia	(a)	(a)						
Georgia	7,494	3,491	61,800	160,698	57,391	27,792	12,400	39,474
Maine	262,925	100,941	144,240	425,363	58,629	49,658	7,651	17,564
Maryland	267,668	55,112	(a)	(a)	(a)	(a)		
Massachusetts	570,251	143,847	291,370	495,156	335,956	394,644	30,782	85,924
Minnesota	(a)	(a)	52,666	120,335	73,120	91,475	191,074	711,895
Missouri	(a)	(a)	(a)	(a)	(a)	(a)		
Montana	991	929	3,844	13,435	(a)	(a)	2,111	9,935
New Hampshire	89,988	78,859	88,150	258,749	81,476	64,549	74,902	187,973
New Jersey	1,577	1,647						
New York	163	206	(a)	(a)	(a)	(a)	(a)	(a)
North Carolina	23,674	4,952	8,500	8,100	82,739	41,931	107,998	351,090
Oklahoma			(a)	(a)	12,307	11,807	2,775	5,550
Oregon			(a)	(a)	(a)	(a)	(a)	(a)
Pennsylvania	1,047,826	87,978	(a)	(a)	(a)	(a)	(a)	(a)
Rhode Island	12,458	4,139	(a)	(a)	105,323	158,702	(a)	(a)
South Carolina	7,308	582	(a)	(a)	(a)	(a)	(a)	(a)
South Dakota							(a)	(a)
Texas	(a)	(a)			27,280	32,050	2,800	17,245
Utah					(a)	(a)		
Vermont	(a)	(a)	191,689	596,757	1,478,623	1,693,653	141,841	506,856
Virginia	14,457	27,217	(a)	(a)	(a)	(a)	(a)	(a)
Washington			8,732	23,703	6,825	5,514	4,310	9,626
Wisconsin	(a)	(a)			15,809	16,774	99,446	521,596
Undistributed	89,310	59,500	85,914	222,509	208,030	183,300	43,790	254,036
	2,598,932	611,489	1,005,398	2,549,805	2,623,435	2,859,140	749,633	2,845,636
Average price		$0.24		$2.53		$1.09		$3.80

State.	Made into paving blocks.		Curbing and flagging.		Rubble.		Riprap.	
	Number of blocks.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
			Linear ft.		*Short tons.*		*Short tons.*	
Arizona							(a)	(a)
California	(a)	(a)	31,384	$18,042	(a)	(a)	323,926	$158,550
Colorado			(a)	(a)				
Connecticut	458,683	$24,921	33,500	17,898	1,810	$1,058	6,007	6,118
Delaware			(a)	(a)	(a)	(a)	(a)	(a)
Dist. of Columbia			(a)	(a)	(a)	(a)	(a)	(a)
Georgia	1,570,680	70,797	371,705	114,123	36,657	23,946	(a)	(a)
Maine	8,781,816	569,300	138,976	74,821			(a)	(a)
Maryland	(a)	(a)			(a)	(a)	(a)	(a)
Massachusetts	6,277,073	365,874	312,062	174,593	8,323	9,607	50,122	41,330
Minnesota	1,231,869	86,875	2,020	2,095	(a)	(a)	42,753	25,635
Missouri	460,260	26,538					(a)	(a)
Montana			(a)	(a)	(a)	(a)		
New Hampshire	4,873,413	213,099	123,647	59,084	1,205	1,162	(a)	(a)
New Jersey							(a)	(a)
New York	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
North Carolina	4,032,200	204,690	286,852	160,663	12,833	19,218	243,703	111,369
Oklahoma					(a)	(a)	(a)	(a)
Oregon			(a)	(a)				
Pennsylvania	(a)	(a)	8,327	7,211	8,339	13,108	(a)	(a)
Rhode Island	330,393	21,142	18,800	10,980	1,605	1,949		
South Carolina	(a)	(a)	33,980	9,258	4,240	5,343	(a)	(a)
Texas			(a)	(a)			(a)	(a)
Vermont	1,191,762	38,781	(a)	(a)			(a)	(a)
Virginia	250,765	10,530	31,848	44,121	1,199	1,999	556	1,092
Washington			(a)	(a)	(a)	(a)	(a)	(a)
Wisconsin	8,834,922	564,466	(a)	(a)	4,306	2,023	(a)	(a)
Undistributed	1,931,115	122,585	8,682	6,555	84,195	120,353	351,385	239,315
	40,224,951	2,319,598	[b] 1,401,783	699,444	164,712	199,766	1,018,452	583,409
Average price	Per M.	57.67		0.50		1.21		0.57

[a] Included in "Undistributed."

[b] Represents approximately 927,380 cubic feet.

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Granite sold in the United States in 1917, by States and uses—Continued.

State.	Crushed stone.						Other value.	Total value.
	Road making.		Railroad ballast.		Concrete.			
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.		
	Short tons.		*Short tons.*		*Short tons.*			
Arizona	(a)	(a)						$135,080
California	412,095	$199,632	(a)	(a)	154,776	$87,961	$6,050	844,453
Colorado							(a)	113,900
Connecticut	(a)	(a)			(a)	(a)	1,969	212,665
Delaware	(a)	(a)			(a)	(a)		216,348
District of Columbia	(a)	(a)			(a)	(a)	(a)	4,615
Georgia	15,816	15,554	21,921	$16,483	93,380	90,359	4,646	568,143
Maine	(a)	(a)			(a)	(a)	7,706	1,254,529
Maryland	267,774	265,208	86,715	53,591	219,770	187,546	13,833	603,069
Massachusetts	59,637	77,154			107,337	138,589	5,793	1,932,511
Minnesota	(a)	(a)	(a)	(a)	(a)	(a)	(a)	1,102,493
Missouri	(a)	(a)						58,241
Montana							(a)	25,831
New Hampshire	33,660	35,152			(a)	(a)	5,093	909,700
New Jersey	(a)	(a)			(a)	(a)	(a)	47,372
New Mexico			(a)	(a)	(a)	(a)		(a)
New York	(a)	(a)	(a)	(a)	(a)	(a)	(a)	182,515
North Carolina	107,768	110,854	(a)	(a)	300,552	340,624	103,703	1,496,541
Oklahoma					(a)	(a)		37,071
Oregon								(a)
Pennsylvania	22,624	31,972	(a)	(a)	6,585	6,702	4,274	290,748
Rhode Island	23,858	36,634			(a)	(a)	(a)	477,779
South Carolina	5,494	5,100	(a)	(a)	223,222	287,541	2,379	427,531
South Dakota								(a)
Texas								95,867
Utah								(a)
Vermont					(a)	(a)	(a)	2,850,615
Virginia	99,639	103,476	103,399	63,409	48,965	52,020	(a)	307,224
Washington					(a)	(a)	(a)	52,053
Wisconsin	54,214	37,095			114,482	98,987	5,621	1,248,112
Undistributed	73,978	83,245	266,632	135,735	140,833	139,997	14,983	60,060
	1,176,557	1,001,076	478,667	269,218	1,409,902	1,430,326	b 176,050	15,544,957
Average price		0.85		0.56		1.01		

a Included in "Undistributed." b Represents approximately 230,000 short tons.

Granite sold in the United States in 1918, by States and uses.

State.	Building.				Monumental.			
	Rough.		Dressed.		Rough.		Dressed.	
	Quantity (cubic feet).	Value.	Quantity (cubic feet).	Value.	Quantity (cubic feet).	Value.	Quantity (cubic feet).	Value.
Arizona					(a)	(a)	(a)	(a)
California	(b)	(b)	b 45,549	b $81,421	75,935	$58,937	66,618	$262,912
Colorado					(b)	(b)	b 29,683	b 112,061
Connecticut	33,811	$21,319	6,812	27,302	17,853	36,271	5,167	33,733
Delaware	(a)	(a)						
District Columbia	(a)	(a)						
Georgia	(b)	(b)	b 64,365	b 77,525	26,295	26,389	23,585	72,910
Maine	198,500	58,305	152,485	579,012	56,658	51,846	7,386	19,518
Maryland	(a)	(a)			(a)	(a)		
Massachusetts	470,376	163,389	227,797	527,773	c 400,475	c 436,383	(c)	(c)
Minnesota	(b)	(b)	b 29,444	b 81,187	83,696	112,923	199,773	903,720
Missouri					(a)	(a)		
Montana			2,970	11,143	(b)	(b)	b 2,957	b 17,653
New Hampshire	17,379	8,095	36,825	135,155	143,303	189,604	89,840	393,557
New Jersey								
New Mexico								

a Included in "Undistributed."
b Rough stone included with dressed stone.
c Dressed stone included with rough stone.

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Granite sold in the United States in 1918, by States and uses—Continued.

State.	Building.				Monumental.			
	Rough.		Dressed.		Rough.		Dressed.	
	Quantity (cubic feet).	Value.	Quantity (cubic feet).	Value.	Quantity (cubic feet).	Value.	Quantity (cubic feet).	Value.
New York	c 45,254	c $15,016	(c)	(c)	(b)	(b)	b 2,659	b $8,311
North Carolina	c 9,028	c 1,710	(c)	(c)	(b)	(b)	b 150,486	b 457,117
Oklahoma	.....	.....	(a)	(a)	c 14,150	c $19,820	(c)	(c)
Oregon	.....	.....	.....	.....	(a)	(a)	(a)	(a)
Pennsylvania	c 1,148,768	c 160,400	(c)	(c)	(a)	(a)	(a)	(a)
Rhode Island	(b)	(b)	b 89,995	b $211,307	c 112,371	c 267,605	(c)	(c)
South Carolina	.....	.....	(a)	(a)	(a)	(a)	.....	.....
South Dakota	.....	.....	.....	.....	.....	.....	(a)	(a)
Texas	(a)	(a)	.....	.....	17,274	21,142	4,300	22,200
Utah	(a)	(a)	.....	.....	(a)	(a)	.....	.....
Vermont	.....	.....	(a)	(a)	1,431,927	2,043,826	81,938	495,437
Virginia	(a)	(a)	.....	.....	(a)	(a)	.....	.....
Washington	.....	.....	(a)	(a)	c 14,461	c 21,744	(c)	(c)
Wisconsin	(a)	(a)	(a)	(a)	17,151	21,823	84,247	613,745
Undistributed	150,409	31,623	41,156	158,114	133,734	165,474	14,509	78,218
Average price	2,098,543	442,586 $0.21	672,470	1,907,210 $2.84	2,655,671	3,408,704 $1.28	702,760	3,556,175 $5.06

State.	Made into paving blocks.		Curbing and flagging.		Rubble.		Riprap.	
	Number of blocks.	Value.	Quantity (cubic feet).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Arizona	.....	.....	.....	.....	.....	.....	(a)	(a)
California	101,375	$5,142	6,140	$3,336	.....	.....	315,445	$166,044
Colorado	.....	.....	.....	.....	.....	.....	.....	.....
Connecticut	(a)	(a)	4,556	7,386	(a)	(a)	5,633	4,625
Delaware	.....	.....	.....	.....	.....	.....	(a)	(a)
District Columbia	.....	.....	.....	.....	(a)	(a)	.....	.....
Georgia	511,100	24,622	82,340	67,504	13,890	$17,538	2,194	5,106
Maine	6,573,847	432,075	97,120	46,374	.....	.....	(a)	(a)
Maryland	(a)	(a)	.....	.....	(a)	(a)	(a)	(a)
Massachusetts	4,523,302	284,634	76,162	85,644	62,086	72,296	(a)	(a)
Minnesota	195,334	14,975	(a)	(a)	(a)	(a)	19,225	12,839
Missouri	236,000	16,435	.....	.....	.....	.....	(a)	(a)
Montana	.....	.....	.....	.....	.....	.....	.....	.....
New Hampshire	3,980,651	213,688	18,480	28,301	3,321	4,828	5,768	4,076
New Jersey	.....	.....	.....	.....	(a)	(a)	(a)	(a)
New Mexico	.....	.....	.....	.....	.....	.....	.....	.....
New York	1,432,018	75,844	.....	.....	(a)	(a)	(a)	(a)
North Carolina	2,265,206	119,188	81,800	69,820	7,568	8,669	5,114	4,209
Oklahoma	.....	.....	.....	.....	(a)	(a)	(a)	(a)
Oregon	.....	.....	.....	.....	.....	.....	.....	.....
Pennsylvania	(a)	(a)	4,300	4,439	(a)	(a)	(a)	(a)
Rhode Island	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
South Carolina	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
South Dakota	.....	.....	.....	.....	.....	.....	.....	.....
Texas	.....	.....	(a)	(a)	.....	.....	(a)	(a)
Utah	.....	.....	.....	.....	.....	.....	.....	.....
Vermont	(a)	(a)	.....	.....	.....	.....	(a)	(a)
Virginia	232,000	11,223	(a)	(a)	(a)	(a)	18,556	31,832
Washington	.....	.....	(a)	(a)	.....	.....	(a)	(a)
Wisconsin	3,491,040	211,187	(a)	(a)	23,104	13,960	(a)	(a)
Undistributed	2,381,653	138,599	11,102	11,577	30,563	34,117	253,020	251,935
Average price	25,923,526	1,547,612 d $59.70	382,000	324,381 $0.85	140,472	151,408 $1.08	624,954	480,666 $0.77

a Included in "Undistributed."
b Rough stone included with dressed stone.
c Dressed stone included with rough stone.
d Per M.

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Granite sold in the United States in 1918, by States and uses—Continued.

State.	Crushed stone.						Other.		Total value
	Road making.		Railroad ballast.		Concrete.				
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	
Arizona									$76,287
California	272,730	$142,166	102,089	$51,338	124,889	$66,590	(a)	(a)	838,786
Colorado							(a)	(a)	112,461
Connecticut	(a)	(a)			(a)	(a)	(a)	(a)	148,317
Delaware	(a)	(a)			(a)	(a)			(a)
District Columbia	(a)	(a)			(a)	(a)			7,585
Georgia	(a)	(a)	20,663	35,660	138,833	209,728	(a)	(a)	558,296
Maine	1,739	2,020	(a)	(a)	14,886	17,983	165	$1,071	1,211,743
Maryland	(a)	(a)	24,161	46,259	30,427	59,348			180,199
Massachusetts	44,400	81,400	(a)	(a)	74,586	147,638	(a)	(a)	1,805,396
Minnesota	(a)	(a)			(a)	(a)			1,167,873
Missouri	(a)	(a)			(a)	(a)			54,523
Montana							(a)	(a)	28,894
New Hampshire	(a)	(a)			8,083	11,274			1,003,328
New Jersey	(a)	(a)			(a)	(a)			31,500
New Mexico			(a)	(a)					(a)
New York	35,200	54,260			(a)	(a)	(a)	(a)	191,551
North Carolina	36,270	55,518	(a)	(a)	252,912	373,289	(a)	(a)	1,155,626
Oklahoma					(a)	(a)	(a)	(a)	116,231
Oregon									(a)
Pennsylvania	6,506	12,035	2,099	3,943	5,727	9,478	(a)	(a)	310,050
Rhode Island	14,640	22,656			500	650	(a)	(a)	525,052
South Carolina	(a)	(a)			166,348	304,197	(a)	(a)	599,864
South Dakota									(a)
Texas									46,297
Utah									(a)
Vermont					(a)	(a)			2,689,652
Virginia	99,058	142,016	59,550	53,050	62,462	82,684			336,696
Washington									65,293
Wisconsin	(a)	(a)			76,996	76,713	(a)	(a)	962,869
Undistributed	166,749	287,649	163,338	139,972	63,632	93,935	171,779	63,161	242,054
	677,292	799,720	371,900	330,222	1,020,281	1,453,507	171,944	64,232	14,466,423
Average price		$1.18		$0.89		$1.42		$0.37	

a Included in "Undistributed."

BUILDING STONE.

The total value of granite sold for building stone in 1918 was $2,349,796, a decrease of $811,498, or 26 per cent, compared with that for 1917, which was 20 per cent less than that for 1916. The decrease was mainly in the value of dressed stone in spite of its increase of 31 cents in average price per cubic foot, whereas the price of rough stone, owing to Pennsylvania's increased output of low-priced material, decreased 3 cents a cubic foot. The increase in general average price, following an increase in 1917, is in keeping with the war conditions which have affected all industries.

The stagnation of the building industry, particularly as regards the erection of buildings which call for granite, continued through the greater part of 1919, and although restrictions on production and transportation were removed, the continued unsettled industrial conditions render a material increase in sales of building granite in 1919 improbable. The predicted period of activity in high-class building began in the fall of 1919 and should grow rapidly, although necessarily prevailing high prices have caused some prospective

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builders to postpone operations or to alter their plans so as to use cheaper material.

The total quantity of building granite marketed in 1918 was 2,771,013 cubic feet, compared with 3,604,330 cubic feet in 1917 and 7,067,060 cubic feet in 1916. The decrease in 1918 was 23 per cent following one in 1917 of 49 per cent. Pennsylvania alone produced nearly 42 per cent of the total quantity, but it was mainly gneiss suitable for foundations and other rough work and averaged only about 12 cents a cubic foot. Pennsylvania's gain of nearly 100,000 cubic feet was due to increased production in the vicinity of Philadelphia, although many of the quarries were reported as idle or only working part of the time. Massachusetts ranked second with a total of 698,173 cubic feet, its rough stone averaging 35 cents and its dressed stone $2.31 a cubic foot. This quantity is less by 163,448 cubic feet than the quantity for 1917, whereas the average price of rough stone increased 10 cents and that of dressed stone 61 cents a cubic foot. The output of Massachusetts was sold mainly as rough building stone, and the greater part of the output was from Rockport, Essex County, and was used in the construction of dry docks. Maine, with 351,075 cubic feet, 56,090 less than in 1917, was the only other State whose total quantity of building stone exceeded 100,000 cubic feet in 1918. The price per cubic foot for rough stone in Maine in 1918, 29 cents, was 9 cents less, and that for dressed stone $3.80, was 85 cents more than in 1917. A little more than one-half the product was sold as rough building stone and the comparatively low average price per ton would indicate sales of stone of lower grade than in 1917. A considerable quantity of dressed granite was shipped as in 1917 to Annapolis, Md., and used in the construction of Bancroft Hall on the Naval Academy grounds. New York and Rhode Island showed considerable gains. In New York there was an increase in the output of stone quarried at the Blackwell's Island Penitentiary. This stone has been used for many years for construction of prison buildings and of the sea wall around the island. In Rhode Island a large quantity of stone was quarried and dressed for use in the Travelers Insurance Co. building, Hartford, Conn.

The most conspicuous declines were in Connecticut, Delaware, Maryland, New Hampshire, and Vermont. In 1917 building stone was reported as sold from 9 quarries in Connecticut and in 1918 from 6 quarries. In New Hampshire 14 companies furnished building stone in 1917, whereas in 1918 there were only 7 quarries from which this product was sold. Vermont, which is primarily a monumental granite State, furnishes building granite mostly for large building contracts, of which there were practically none in 1918. As to one State, in which the stone is also sold locally, the statement was made that owing to the cost of all building material and to lack of labor, stone was furnished for only one piece of local work, whereas ordinarily material was required for 20 to 40 foundations.

MONUMENTAL STONE.

Monumental granite remained about stationary in quantity and increased in value. The total quantity sold in 1918 was 3,358,431 cubic feet, only 0.4 per cent less than that in 1917, which was 6.6 per

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cent less than that in 1916. The total value in 1918 was $6,964,879, a gain of 22 per cent, following a gain of 7.8 per cent in 1917. The average price per cubic foot of rough stone increased 19 cents, and that of dressed stone $1.26. Transportation conditions, though still restricted, were less unfavorable than in 1917, and the demand, dependent more upon individual resources than upon industrial conditions, continued in spite of the necessary increase in price.

Monumental stone includes the stone used for mausoleums, and there was reported as sold for this purpose in 1918 252,329 cubic feet, valued at $788,252, of which 156,631 cubic feet, valued at $725,225, was dressed stone. This does not represent all the stone sold for this purpose, as several of the producers selling rough stock were unable to separate their product. North Carolina, California, Vermont, and New Hampshire were the principal States reporting sales for mausoleums, but they were also reported from Arizona, Colorado, Connecticut, Georgia, Maine, Massachusetts, and Rhode Island.

After the signing of the armistice and with the first coming back to their old trades of the men who had left the quarries for service in the Army or Navy or who had worked at other trades during the war, the wage question became very pertinent in all the large stone quarrying and manufacturing districts, particularly in those producing monumental granite. In the Barre granite district negotiations between the Granite Manufacturers' Association and the Barre branch of the Granite Cutters' International Association resulted in an agreement whereby after January 1, 1919, the Barre granite workers received a minimum wage of $5.52.[7] This meant that granite cutters, polishers, and tool sharpeners received an increase of 72 cents per day. The following figures show the wages granted to cutter's apprentices January 1, 1919, August 1, 1919, and September 2, 1919.[8]

Wages of cutter's apprentices, 1919.

	Jan. 1.	Aug. 1.	Sept. 1.
First 6 months	$1.90	$2.09	$3.00
Second 6 months	2.10	2.31	3.25
Third 6 months	2.30	2.53	3.50
Fourth 6 months	2.60	2.86	4.00
Fifth 6 months	2.90	3.19	4.50
Sixth 6 months	3.25	3.58	5.25

It was stated that this material increase in wage scale was granted in order to encourage young men to enter the granite-cutting trade.

At Concord, N. H., a new wage scale providing for a minimum of $5.52 went into effect February 1, 1919. This was practically the same as that adopted at Barre.

At Quincy, Mass., the cutters demanded $6 a day as the minimum wage, which was refused by the employers, who offered $5.52, as at Barre. The men refused this and quit work December 1. This strike lasted well into 1919. The increase asked for represented a wage increase of about $1.20 a day. The Quincy district, on account of its nearness to the Fore River and Squantum shipyards, suffered more than any other district from labor difficulties.

[7] Monumental News, January, 1919. [8] Monumental News, October, 1919.

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Vermont, the leading State, produced about 47 per cent of the total quantity of monumental stone; but as more than 94 per cent of this quantity was sold as rough stone, the State is here credited with only 36 per cent of the total value. The total output in 1918 was 1,563,865 cubic feet, valued at $2,539,263, a decrease of 56,599 cubic feet (3.5 per cent) in quantity but an increase of $338,754 (15 per cent) in value. The rough stone sold increased both in quantity and value, but a decrease of over 42 per cent in quantity of dressed stone caused a decrease in value in spite of increase in average price.

The average prices of Vermont monumental granite from 1913 to 1918 are given below as showing the effect of trade conditions in the stone industry:

Average price of Vermont monumental granite, 1913–1918, per cubic foot.

Year.	Rough.	Dressed.	Average.
1913	$0.98	$3.37	$1.09
1914	1.01	2.99	1.11
1915	1.00	3.69	1.17
1916	1.04	3.66	1.18
1917	1.15	3.57	1.36
1918	1.38	6.05	1.62

Barre is the chief center of the monumental industry in Vermont, and on account of the large quantity of rough stone bought in the vicinity by companies from the quarrymen as rough stock, the following tabular statement furnished by Athol R. Bell, secretary of the Barre Quarriers & Manufacturers' Association, will give an idea of the size of the entire granite industry in 1917 and 1918 in that district, which includes Barre, Williamstown, East Barre, Montpelier, West Berlin, Northfield, and Waterbury.

Estimated output of monumental granite in the Barre district in Vermont in 1917–18.[a]

	1917	1918
Total quarry output (rough stock)....cubic feet..	1,560,000	1,654,800
Shipped out of Barre district in rough....do....	260,000	248,222
Manufactured in Barre district....do....	1,300,000	1,406,578
Light stock consumption in district....do....	800,000	879,111
Dark stock consumption in district....do....	500,000	527,467
Number of cutters in district	2,550	1,500
Average daily wage	$5.00	$5.00
Average number of days worked annually	280	260
Total pay roll for year	$3,570,000	$1,100,000
Estimated overhead—50 per cent cutters' wages	$1,785,000	$2,050,000
Estimated light stock valuation, 800,000 cubic feet, at $1.25	$1,000,000	.....
Estimated dark stock valuation, 500,000 cubic feet, at $1.45	$725,000	.....
Estimated polishing cost of 500,000 feet, 1 cubic foot averaging 2 cubic feet, at $1	$1,000,000	.....
Output from saws—one saw equaling 10 men—13 saws in district take place of 130 men at average cost of $6.50 per man and working 280 days a year	$236,000	.....
	$8,316,000	.....

[a] These estimates do not include production by other machinery, such as lathes and sand-blast machines, nor do they include valuation of rough stock shipped outside of the Barre district.

Mr. Bell states that 56 quarries were operated during 1918. These were evidently operated by the 22 companies that reported to the Geological Survey. Twenty-seven active quarry companies reported

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in 1917. One hundred and forty-six manufacturing firms were active in 1918. The apparent discrepancy between two statements on page 1222 of the quantity of manufactured stone produced in the Barre district in 1918 results from the fact that some companies which quarry and manufacture stock report to the Survey only the quantity and value of the rough stone from the quarry and others report only that of finished stock. The figures in the foregoing table represent the entire quantity manufactured, most of it by companies which buy their rough stock and are not included in the Survey's list of producers. The difference beween the figures for rough stock in the foregoing table and the total quantity reported to the Survey represents principally the stone wasted in manufacturing.

Regarding industrial conditions in 1918, Mr. Bell says:

> The Barre granite industry in 1918 was naturally subject to a good many of the proscriptions which necessity imposed upon nonessential industries. Our members, while realizing that the loss to them would be measurably irreparable, patriotically cooperated with the Government in sending men, many of them skilled pneumatic tool operators, to the shipyards. In addition there was the prevailing shortage of unskilled labor at the quarries, and of course many men were with the colors.
>
> The arduous winter of 1917–18 cut down the number of working days to 260, the average being 280. Yet the steady introduction of labor-saving machinery partially closed up the gap caused by the decimation of man power in the industry, prolonged suspensions due to extreme weather and fuel orders, and the inevitable shortage of cars.

Massachusetts, which ranked second in quantity of monumental stone made an increase of 33,737 cubic feet, but its total quantity was only about one quarter as much as Vermont's. The total State value was exceptional in decreasing $44,185, and reducing its rank in value from fourth to sixth, owing to the greater output of rough stone, and greatly reduced output of dressed stone.

The total output was 400,475 cubic feet valued at $436,383; an average price of $1.09 a cubic foot. The chief producing district is at Quincy, Norfolk County, although a considerable quantity is produced at Rockport, Essex County, and Milford, Worcester County, with smaller producing localities elsewhere.

Minnesota continued to rank third in quantity and second in value, increasing in both respects. From 1912 to 1916 Minnesota showed steady increase in monumental stone produced, but in 1917 there was a decrease of 20 per cent in quantity, though an increase of nearly 21 per cent in value. In 1918 the output was 283,469 cubic feet, valued at $1,016,643. Although the quantity sold did not equal that of 1916, the total value exceeded $1,000,000 for the first time. The average price was $3.59 per cubic foot, 55 cents more than in 1917. The quarries near East St. Cloud, Sherburne County, and St. Cloud, Stearns County, produced 268,651 cubic feet, valued at $964,290. This represents 95 cent of both the quantity and the value of the monumental stone quarried in the State. Sales of granite for monumental purposes were reported also from quarries at Sauk Rapids, Ortonville, Little Falls, North Redwood, and Morton.

Other States with increase in quantity in 1918 were New Hampshire, Rhode Island, and California. New Hampshire's monumental stone came from Concord, Merrimack County; Milford, Hillsboro

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County; Fitz William, Cheshire County; and Redstone, Carroll County. Rhode Island's output was from Westerly. California's output was principally from Raymond, Madera County, but was also sold from quarries near Academy, Fresno County; Penryn and Rocklin, Placer County; Porterville, Tulare County; and included small outputs from Riverside and San Bernardino counties. The value of monumental stone increased in all the more important States, except Massachusetts. New Hampshire's value more than doubled.

PAVING BLOCKS.

PRODUCTION.

Granite paving blocks, valued at $1,547,612 and numbering 25,923,526, were sold in 1918. The quantity of paving blocks produced represented a decrease of 36 per cent, compared with 1917,

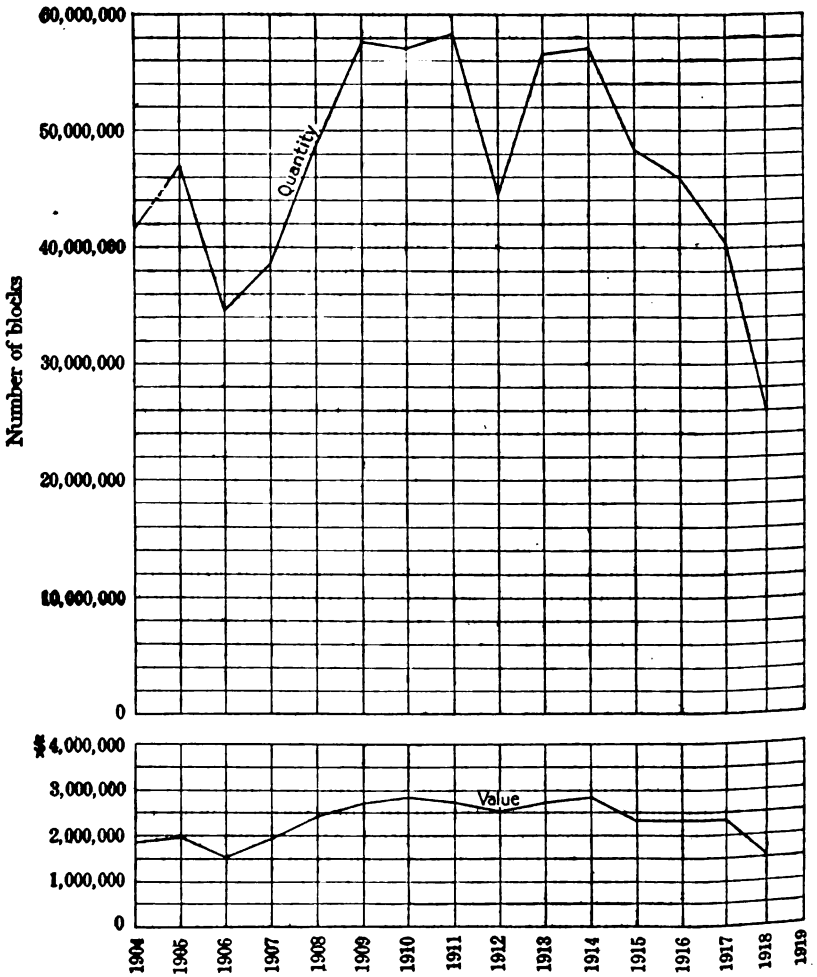

FIGURE 112.—Quantity and value of granite paving blocks sold, 1904–1918.

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which in turn showed a decrease of more than 12 per cent, compared with 1916. The value in 1918 was 33 per cent less than that in 1917, which was practically the same as in 1916 and 1915. The average price per thousand during these few years was $48.85 in 1915, $50.73 in 1916, $57.67 in 1917, and $59.70 in 1918, the last being the highest price ever recorded. These figures do not include sales of "durax" blocks. The trend of the paving-block industry is illustrated in figure 112.

Sales were reported from 17 States in 1918, as in both 1916 and 1917. New York and California, whose outputs in 1917 were not disclosed, were the only States to show increase in quantity and value. New Hampshire and Virginia showed small increase in value. Wisconsin, which had been the leading State in 1916 and 1917, ranked fourth in 1918, sustaining a decrease of more than 5,000,000 blocks. Maine regained first place, in spite of a decrease of more than 2,000,000 blocks, and Massachusetts advanced to second place, in spite of a decrease of more than 1,750,000 blocks. New Hampshire, which ranked third in 1918, showed the smallest decrease of any of the leading States—less than 900,000 blocks. North Carolina, Georgia, and Minnesota each showed a decrease of more than 1,000,000 blocks, and the last two became comparatively small producers in 1918. These large decreases reflect the great curtailment of street maintenance and improvement in the larger cities during the war, and presumably forecast a rapid recovery as soon as stable industrial conditions are again established, although in some cities, particularly Boston, the reusing of old blocks in 1919 has continued the restricted production of many producers in New England.

The average price per thousand, as shown below, was lowest in the Southeastern States and California. It was highest in the Central States, and ranged from low to moderate in the New England States and New York.

Average price per thousand of granite paving blocks in 1917 and 1918.

State.	1917	1918
New England States:		
Connecticut	$54.33	$53.45
Maine	61.83	65.73
Massachusetts	58.29	62.93
New Hampshire	43 73	53.68
Rhode Island	63.19	66.25
Vermont	32.54	43.72
Middle Atlantic States:		
Maryland	65.98	68.86
New York	68.78	52.96
Pennsylvania	57.70	83.33
Southeastern States:		
Georgia	45 07	48.17
North Carolina	50.76	52.62
South Carolina	40.00	42.09
Virginia	41.99	48.39
Central States:		
Minnesota	70.52	76.66
Missouri	57.66	61.64
Wisconsin	63.89	60.49
Western States:		
California	38.46	50.72
United States	57.67	59.70

Increase in price of the cheapest blocks was greater than that of the moderate and high-priced blocks. Thus, New Hampshire's price increased nearly $10, Virginia's more than $6, and California's more

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than $12 a thousand; whereas, the increase in the moderate prices ranged from less than $1 to more than $4. New York's decrease of nearly $16 was due to a quantity of blocks manufactured from material excavated in New York City. Wisconsin was also exceptional with a decrease of more than $3.

DISTRIBUTION.

The distribution of granite paving blocks from quarry districts to markets is shown in Plate XIV. The New England States produced nearly 64 per cent of the granite paving blocks manufactured in 1918. All of these producing localities are easily accessible to New York and Boston by water or short railroad transportation, and the greater part of the output is therefore shipped to these two cities either for use in the city and its suburbs or for reshipment and distribution to interior markets.

New York.—In 1918 New York and vicinity (including Newark and Hoboken, N. J., Yonkers, Brooklyn, and Long Island City, N. Y.) received nearly 9,400,000 blocks, of which 7,550,000 came directly to New York City. More than 5,630,000 blocks were shipped from West Sullivan, Long Cove, Somes Sound, Vinal Haven, and St. George, Me., to the New York district, 330,000 blocks going to Newark, N. J. The Massachusetts quarries furnished 1,830,000 blocks to this district from Becket and Rockport. Nearly 500,000 blocks from New Hampshire quarries, at Milford and Concord, were shipped to New York. Waterford, Conn., Westerly, R. I., and the New York quarries supplied the remainder.

Boston.—Nearly 5,600,000 blocks were shipped to the Boston district. This includes, besides Boston, small shipments to Quincy, Taunton, Salem, Lawrence, and other neighboring cities and towns. More than 460,000 blocks were shipped to Boston from the Maine quarries, nearly 1,342,000 from the Massachusetts quarries, more than 2,460,000 from the New Hampshire quarries, and the entire output of the Vermont quarries.

Philadelphia.—Of nearly 1,118,000 blocks shipped to the Philadelphia district, including Camden, N. J., and vicinity, and Chester, Pa., nearly 475,000 blocks came from Maine, 270,000 from Massachusetts, 189,000 from New Hampshire, and the remainder from Connecticut and as local shipments from Holmesburg and St. Peters, Pa.

The remainder of the paving blocks produced in New England in 1918 was distributed in supplying local demands or as small shipments to neighboring States. Connecticut paving blocks found further consumption at Ansonia, Conn., and Providence, R. I., and vicinity. Maine blocks were shipped only to the three large districts, and Portland, Me., was supplied with paving blocks from New Hampshire. In Massachusetts Fitchburg, Springfield, and Westford were supplied with local blocks and New Bedford and Fall River, although producing localities, reported home consumption of practically their entire product. New Hampshire blocks were reported as shipped to several towns and cities in Massachusetts, New York, and Rhode Island, as well as used in supplying local demands and those of the large centers. Rhode Island blocks from Westerly were

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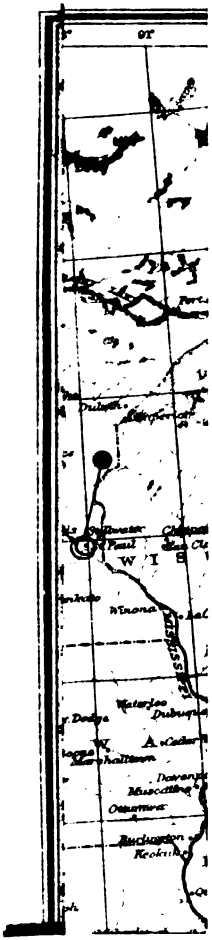

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shipped to Providence and to the New York district. Vermont's output found its entire market in Boston. The principal market for New York paving blocks was the New York City district, but some were shipped from Alexandria Bay to Cleveland and local markets. Paving blocks made in Pennsylvania at Holmesburg and St. Peters supplied the markets of Philadelphia and Harrisburg, Pa., and Camden, N. J. The blocks made in Maryland were all sold in Baltimore near the place of production. Virginia's output from near Richmond supplied the local market and blocks were also shipped to Norfolk and Petersburg. North Carolina shipped to the Virginia markets and to western Pennsylvania, Cleveland, Ohio, Louisville, Ky., and Indianapolis and Kokomo, Ind. Paving blocks made in South Carolina found markets at considerable distance in Cleveland, Ohio, and Fort Wayne, Ind., and those of Georgia, besides supplying Atlanta, were shipped to Cincinnati, Ohio, Louisville, Ky., Indianapolis, Ind., and Chicago, Ill. In previous years, before the restrictions on transportation, blocks from North Carolina, South Carolina, and Georgia supplied markets in other cities of the Middle Atlantic and Eastern Central States.

The paving blocks produced at Graniteville, Farmington, and Doe Run, Mo., supplied the St. Louis market, and shipments were also made to Peoria, Ill. The blocks produced in Minnesota, at St. Cloud, except a small local consumption, were all sent to St. Paul and Minneapolis. Wisconsin, usually a large producer of paving blocks, decreased 60 per cent in output in 1918. This followed a decrease of 20 per cent in 1917.

One of the largest Wisconsin producers of paving blocks directed most of its energies to the production of ganister.[9] It is thought that about 250,000 Wisconsin blocks were shipped to Milwaukee, Wis.; 367,000 to Detroit, Mich.; 1,602,000 to Cleveland, Ohio; and 2,413,653 to Chicago, Ill. These cities are well located for the reshipment of blocks, so it is not possible to give their exact consumption. The granite paving-block industry in California was confined to three localities in southern California, which shipped to southern California to San Diego and Los Angeles, and one at Rocklin in Placer County, which shipped probably to the cities on San Francisco Bay.

The paving-block supply of the large cities is sometimes supplemented by blocks of stone taken from old structures that are being torn down. According to Stone,[10] the Board of Public Works of San Francisco was planning to let a contract to cut paving blocks from the stone once forming the foundation of San Francisco's old city hall at a cost of $37.50 a thousand. This would entail a considerable saving, the market price being $60 a thousand and the blocks hard to obtain. These blocks were to be used for "leaders," the blocks which lie next to the rail and receive the hardest usage, along the lines of the municipal railway. Old foundations have also been recut for paving blocks in the New York City district.

Durax paving blocks sold in 1918 amounted to 1,337 short tons, valued at $9,106, of which the greater part was produced in North Carolina and the remainder in Maine.

[9] Stone, August, 1918, p. 317.

[10] Stone, August, 1917, p. 419.

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RUBBLE AND RIPRAP.

Rubble and especially riprap both decreased in quantity and value in 1918. Massachusetts, the leading producer of rubble, produced slightly more than 62,000 short tons, after an insignificant production of 8,000 tons in 1917. Georgia, which led with nearly 37,000 tons in 1917, produced less than 14,000 tons in 1918. These figures once more illustrate the local and temporary conditions affecting the quarrying of rubble.

California was the only State with a considerable production of riprap in 1918, its quantity decreasing more than 8,000 short tons. The large decrease for the country was presumably due to curtailment of river and harbor improvement work.

CURBING AND FLAGGING.

Curbing and flagging decreased 59 per cent in quantity and 54 per cent in value in 1918, following decreases of 30 per cent and 16 per cent, respectively, in 1917. This continued decrease was due to the same general causes that affected paving. Georgia, which has been the leading State, underwent the greatest decrease, 53 per cent in quantity and 41 per cent in value, being passed by Maine in quantity and nearly equaled by North Carolina. Massachusetts, which ranked second in quantity in 1917, decreased 49 per cent and ranked fourth in 1918. North Carolina, although decreasing 40 per cent, ranked third in 1918, and New Hampshire, which ranked fifth in 1917, decreased 69 per cent and became an insignificant producer in 1918. Only one State, North Carolina, reported an output of flagging in 1918.

CRUSHED STONE.

Crushed granite represented 54 per cent of the total quantity and 18 per cent of the total value of granite sold in 1918. The production decreased 32 per cent in quantity and 4 per cent in value, following respective decreases of 35 per cent and 24 per cent in 1917. Crushed granite for concrete continued to be the leading product and the only one to exceed 1,000,000 tons, its quantity in 1918 decreasing 28 per cent but its value increasing 1.6 per cent, owing to an increase of 41 cents in the average price per ton. Road metal decreased 42 per cent in quantity and 20 per cent in value, its average price per ton increasing 33 cents. Railroad ballast decreased 22 per cent in quantity and increased 23 per cent in value, its average price per ton increasing 33 cents. The general average price of crushed granite in 1918 was $1.25 a ton, compared with 88 cents in 1917 and 75 cents in 1916. The decline in the use of crushed granite during the war and its proportion of the total quantity of crushed stone is shown in figure 117, page 1310.

OTHER USES.

Granite for "other uses" decreased 25 per cent in quantity and 64 per cent in value in 1918. A considerable quantity of stone quarried near Granite, Okla., by the inmates of the State reformatory and therefore held at less than market value represents more than half of the quantity. This stone was used in the construction of the State capitol at Oklahoma, and on account of the extremely low price was classed under "other" instead of under rubble. Other products

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included are stone finely crushed for poultry grit and for artificial stone; stone powdered for use in soap; broken stone used in filtration plants; and stone for the manufacture of rolls used in the manufacture of paper and in chocolate machinery. Since 1916 granite has been reported as used for the manufacture of rolls and scotia beds for grinding chocolate. According to the Monumental News,[11]

this is an entirely new feature of the American granite business. Heretofore the chocolate producers have been using for this purpose a stone produced in Germany. Both the rolls and the beds must be corrugated and ground into each other so as to mesh accurately. An entirely new machine is being built for this purpose (by Jones Bros. Co., at Barre, Vt.). The rolls must all be drilled for the shaft, and a battery of core drills has been built along original lines. It is probable that there will be considerable business of this kind in the future.

Besides Barre, Vt., the quarries at Waterford, Conn., have furnished stone for this purpose.

WAR USES.

Granite has received some attention as a war material. Besides being used in the construction of dry docks by the Navy, it has also been considered, likewise by the Navy, for the erection of nitric acid towers. Trouble with leakage through the numerous joints where chemical brick was used led to the consideration of natural stone that could be obtained in large blocks. Quartzite would be the first choice; but quartzites that are sufficiently nonporous and can be obtained in blocks of desired size are scarce and less conveniently located with respect to the markets in question than are many granites. It is also doubtful if any but granite quarries are equipped to furnish the large blocks specified. At the request of the Navy Department, therefore, experiments on the resistance of granite to corrosion by nitric acid were conducted by George Steiger and G. F. Loughlin of the United States Geological Survey. Preliminary treatment of several granites with 1:1 nitric acid gave a wide range of results, some granites undergoing more or less superficial disintegration within a day or two, some resisting the acid for more than two months with no apparent deterioration other than slight coloration of the acid, and others disintegrating rapidly for a short time. When the granites that showed considerable disintegration were removed from the acid, thoroughly cleaned, and immersed in fresh acid, most of them underwent no further disintegration. Samples immersed for 13 months, then dried and broken open, were bleached to a depth of one-eighth to one-fourth of an inch, but were quite unaffected at greater depth, and most of those having rubbed or polished surfaces gave little or no evidence of superficial disintegration. One sample was thoroughly disintegrated by repeated exfoliation. Biotite (black mica) was the most decomposable mineral present, its decomposition being accompanied by a swelling that was the main cause of disintegration. The development of rift and grain cracks along the rough broken or tooled surfaces was also an important factor in connection with the biotite, and the extent of the disintegration evidently depended on the depth to which these cracks allowed the acid to reach the biotite. In the sample which completely disintegrated biotite was in such large grains and so abun-

[11] Monumental News, June, 1918, p. 254.

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dant that new grains were continuously exposed to attack as disintegration proceeded. Quantitative determination of the constituents dissolved showed that other minerals including muscovite, amphibole, pyroxene, and alkalic feldspars were slightly attacked by nitric acids, but the quantity of new material dissolved decreased with each successive treatment. Results of this investigation, so far as it has gone, show that a few granites are practically as suitable as quartzite for the walls of nitric acid towers, and that those granites that underwent considerable superficial disintegration at first lost little if any more material in solution than those that showed little or no disintegration. In other words, as soon as the acid had penetrated to the slight depth of the minute cracks developed on the tooled or roughly fractured surface, disintegration ceased and solution proceeded so slowly as to be negligible. At the rate of solution after a month's immersion, the surface would be worn away at the rate of one-sixth of an inch a year; but the appearance of cubes having smooth surfaces after immersion for a year showed no visible loss of surface other than the removal of a few grains of biotite, and the extent of the corrosion subsequent to the decomposition of the superficial biotite is practically negligible.

NOTE ON THE FOREIGN GRANITE INDUSTRY.

According to the Quarry,[12] the granite industry at Aberdeen, Scotland, was in a worse condition in 1918 than it had been for many years. The effects of the war, following closely a rather dull period, greatly reduced the demand for building stone and paving blocks, depleted the labor supply, and increased the cost of operation. Cessation of imports of rough Scandinavian granite and great depletion of stocks of it, left manufacturers more dependent upon the comparatively expensive native stone. Exports to the United States, formerly an important customer, had declined to insignificance.

BASALT AND RELATED ROCKS (TRAP ROCK).

GENERAL STATISTICS.

The group of road-building rocks which includes basalt, diabase, and some other dark igneous rocks that are very similar in mineral composition and physical properties furnished 9 per cent of the value of all the stone produced in the United States in 1918.

Basalt and related rocks (trap rock) sold in 1917 and 1918, classified by uses.

Use.	1917		1918	
	Quantity.	Value.	Quantity.	Value.
Building stone.....cubic feet..	912,447	$39,200	165,377	$10,808
Approximate equivalent in short tons.....	82,120	.....	14,880	.....
Paving blocks.....number..	1,450,500	52,755	404,965	18,308
Approximate equivalent in short tons.....	16,320	.....	4,550	.....
Rubble.....short tons..	326,974	328,561	130,544	267,160
Riprap.....do....	565,553	506,616	119,426	116,050
Crushed stone.....do....	8,067,582	6,600,957	6,556,888	7,306,168
Other.....do....	a 45,000	42,796	32,946	63,786
Total (quantities approximate, in short tons).....	9,103,580	7,570,885	6,859,200	7,782,280

a Estimated.

[12] Quoted in Stone, October, 1918, pp. 460–461, and the Monument Reporter, November, 1918, p. 13.

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Value of basalt and related rocks (trap rock) sold in the United States in 1917.

State.	Building.	Riprap and rubble.	Paving.	Crushed stone.			Other.	Total.
				Road metal.	Railroad ballast.	Concrete.		
Arkansas	(a)	(a)		(a)	(a)	(a)	(a)	(a)
California	(a)	$206,536	$27,074	$219,542	(a)	$656,134		$1,150,248
Colorado						(a)		(a)
Connecticut	$25,362		4,387	480,109	$119,597	337,865	$7,000	974,320
Hawaii	(a)	227,267		(a)		165,665	(a)	433,453
Massachusetts	(a)			379,275	10,885	138,302	(a)	535,437
Michigan		(a)		64,098		(a)		70,197
Minnesota	3,731			6,770	(a)	(a)		141,380
New Jersey	(a)	3,408	6,377	823,832	149,206	385,697	(a)	1,372,956
New York				191,675	33,000	447,775	12,100	684,550
Oregon b		115,921		95,449	(a)	103,081	(a)	327,770
Pennsylvania	6,009	9,262		530,287	397,616	223,290	12,200	1,178,664
Texas b		(a)		(a)	(a)	(a)		(a)
Washington b		258,777		36,054		28,583		328,331
Wisconsin				(a)	(a)	(a)		(a)
Undistributed	4,098	14,006	14,917	296,997	112,155	168,018	11,496	323,579
	39,200	835,177	52,755	3,124,088	822,459	2,654,410	42,796	7,570,885

a Included in "Undistributed."
b Small values not enumerated included in "Undistributed."

Basalt and related rocks (trap rock) sold in the United States in 1918.

State.	Building.		Riprap and rubble.		Paving.		Crushed stone.	
							Road metal.	
	Quantity (cubic feet).	Value.	Quantity (short tons).	Value.	Number of blocks.	Value.	Quantity (short tons).	Value.
Arkansas							(a)	(a)
California	(a)	(a)	18,738	$16,558	(a)	(a)	380,059	$267,543
Colorado								
Connecticut	96,305	$4,834	(a)	(a)			336,806	320,403
Hawaii			(a)	(a)			(a)	(a)
Idaho							(a)	(a)
Maryland			(a)	(a)			62,055	88,918
Massachusetts	(a)	(a)	(a)	(a)			364,409	453,363
Michigan							23,686	32,605
Minnesota	(a)	(a)	(a)	(a)			(a)	(a)
New Jersey	(a)	(a)			(a)	(a)	419,063	591,997
New York							215,500	279,000
Oregon			(a)	(a)			62,056	62,701
Pennsylvania	29,522	4,240	7,359	9,718	(a)	(a)	346,911	453,671
Texas			(a)	(a)			(a)	(a)
Washington			98,622	90,347	(a)	(a)	29,427	29,653
Wisconsin			(a)	(a)			(a)	(a)
Undistributed	39,550	1,734	125,251	266,587	404,965	$18,308	244,868	302,420
	165,377	10,808	249,970	383,210	404,965	18,308	2,484,840	2,882,274
Average price		.07		1.53		b 45.21		1.16

a Included in "Undistributed." b Per M.

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Basalt and related rocks (trap rock) sold in the United States in 1918—Contd.

State.	Crushed stone.				Other.		Total value.
	Railroad ballast.		Concrete.		Quantity (short tons).	Value.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.			
Arkansas	(a)	(a)	(a)	(a)			(a)
California	73,147	$56,960	887,964	$652,781			$1,005,112
Colorado	(a)	(a)	(a)	(a)			(a)
Connecticut	91,898	93,504	450,718	428,705	(a)	(a)	848,442
Hawaii			97,753	140,836			466,093
Idaho			(a)	(a)			(a)
Maryland	(a)	(a)	214,239	279,566			425,817
Massachusetts	(a)	(a)	136,778	153,026	(a)	(a)	610,161
Michigan			(a)	(a)	(a)	(a)	53,269
Minnesota			(a)	(a)			(a)
New Jersey	233,517	282,402	375,440	573,718	13,249	$26,498	1,475,358
New York	54,250	60,500	(a)	(a)			621,750
Oregon	(a)	(a)	80,073	77,969	(a)	(a)	160,586
Pennsylvania	426,030	467,666	326,362	402,742	12,000	16,996	1,355,332
Texas	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Washington	(a)	(a)	26,969	23,779	(a)	(a)	154,205
Wisconsin							(a)
Undistributed	144,598	143,025	451,812	586,725	7,697	20,292	606,155
	1,023,440	1,104,047	3,048,608	3,319,847	32,946	63,786	7,782,280
Average price		1.08		1.09		1.94	

a Included in "Undistributed."

All these products decreased greatly in quantity and all but crushed and "other" stone in value. The increased value of these products was sufficient to increase the total value 2.8 per cent, whereas the total quantity decreased nearly 25 per cent. The increase in value followed decreases of 1.2 per cent in 1917 and nearly 10 per cent in 1916, and brought the total value above that of either of these years, though not up to that of 1915, 1914, or 1913.

Crushed stone represented nearly 96 per cent of the total quantity and 94 per cent of the total value of this group of rocks, and 22 per cent of the quantity and 26 per cent of the value of total crushed stone sold in 1918. Crushed basalt and related rocks decreased 19 per cent in quantity in 1918, after a decrease of 10 per cent in 1917. Its value, however, increased 11 per cent in 1918 after an increase of 1 per cent in 1917. The average price was $1.11 in 1918, compared with 82 cents in 1917 and 73 cents in 1916. Road metal decreased 34 per cent in quantity and 8 per cent in value, after corresponding decreases of 12 per cent and 2 per cent in 1917. Crushed stone for concrete, however, decreased 8 per cent in quantity, after a decrease of 9 per cent in 1917, and again increased in value (25 per cent), after an increase of 3 per cent in 1917. Railroad ballast increased in both quantity (0.4 per cent) and value (34 per cent) in 1918, after decreasing 7 per cent in quantity and increasing 8 per cent in value in 1917. The gains in value of railroad ballast and concrete aggregate were made principally in New Jersey and Pennsylvania and to a less extent in Connecticut and Massachusetts, whose quarries were well situated for supplying the congested railroad and manufacturing region. California, Massachusetts, and New York were the only States whose value of road metal increased.

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New Jersey and Pennsylvania, the two leading States, and Massachusetts, which ranked fifth, showed increase in total value, as did the States whose individual values are not disclosed. California, in spite of decrease in all products, furnished by far the greatest quantity of concrete aggregate and next to the greatest quantity of road metal. Its riprap and rubble, however, declined to insignificance. Washington, Oregon, and Hawaii, which have been the other important producers of riprap, also showed great declines, and Washington was the only State with a noteworthy production in 1918.

Paving blocks and building stone also declined greatly in quantity and value. Paving blocks decreased 72 per cent in quantity in 1918, following decreases of 3 per cent in 1917 and 51 per cent in 1916. Paving blocks were produced in the same States as usual, but the number of producers has so generally decreased that only the country's total can be given without disclosing individual production. The average price per thousand was $45.21 in 1918 compared with $36.37 in 1917 and $38.39 in 1916. Connecticut furnished by far the most building stone, but its value was nearly equaled by Pennsylvania, whose stone averaged 21 cents a foot, whereas the average for the country was only 7 cents. Building stone was almost entirely rough stone for foundation work, but Pennsylvania's included a quantity of dressed stone that averaged more than 70 cents a cubic foot.

"Other" stone in 1918 included vesicular basalt quarried in Washington for use in paper-making machinery, which was formerly supplied by German stone.

Maryland appears for the first time among the States producing basalt and related rocks. Its product is gabbro-diorite, quarried at several places in its eastern part. This stone has heretofore been reported as crushed granite. In fact some of the producers may work quarries of both kinds of rocks, or may abandon a quarry of one kind in one year and open a quarry of the other kind the next. The ratio of gabbro-diorite to granite produced in Maryland may therefore be expected to fluctuate.

Value of basalt and related rocks (trap rock) sold in the United States, 1914–1918.

State.	1914	1915	1916	1917	1918
Arkansas	$233,987	$147,442	$185,360	(a)	(a)
California	1,589,821	1,136,589	938,140	$1,150,248	$1,005,112
Colorado	.....	(a)	(a)	(a)	(a)
Connecticut	549,156	698,744	788,661	974,320	848,442
Hawaii	88,417	195,500	381,771	483,453	466,098
Idaho	.....	.....	(a)	.....	(a)
Maryland	(b)	(b)	(b)	(b)	425,817
Massachusetts	601,330	632,989	647,044	535,437	610,161
Michigan	34,406	105,855	83,072	70,197	53,269
Minnesota	77,338	80,640	139,963	141,380	(a)
New Jersey	1,164,529	1,281,545	1,293,217	1,372,956	1,475,358
New York	895,147	762,370	956,100	684,550	621,750
Oregon	397,824	739,380	303,909	327,770	160,588
Pennsylvania	1,076,001	1,101,778	1,041,203	1,178,664	1,355,332
Texas	(b)	(a)	(a)	(a)	(a)
Washington	1,068,042	1,452,869	754,831	328,331	154,205
Wisconsin	(b)	(a)	(a)	(a)	(a)
Undistributed	.....	153,521	162,126	323,579	606,155
	7,865,998	8,489,222	7,666,207	7,570,885	7,782,280

aIncluded in "Undistributed." bIncluded under granite.

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WAR USES.

Soon after the war broke out the United States Geological Survey received inquiries for a domestic supply of vesicular basalt to take the place of stone hitherto imported in small quantity from Germany for use as bedplates and beater rolls in paper-making machinery. The vesicles of imported stone are of irregular shape and sharp edged and are particularly efficient in pulling apart or shredding the wood pulp. As such vesicular stone was not like the stone ordinarily quarried for crushing there was some difficulty in getting satisfactory samples by correspondence with producers. Eastern deposits of course were too amygdaloidal to be satisfactory. Vesicular rock is abundant in the West, and finally stone much like the German stone was located in Washington. This stone is now quarried at two localities in Washington to supply the demand of the paper industry.

Another proposed use of vesicular basalt during the war was crushed stone to serve as lightweight aggregate for concrete ships. The variety that has given best results in the laboratory is highly vesicular, resembling a rubber bath sponge, and is found in certain basalt cinder cones of the Southwest. Only a small porportion of the cinder cones contain stone of this character in commercial quantity, but deposits close to main railroad lines and large enough to supply the estimated needs of all the Government shipyards for at least a few years were located in New Mexico and southern California. Another deposit worthy of consideration is the cinder cone of Mount Tabor, just east of Portland, Oreg. While search for these deposits was going on, experiments with vesicular burned clay for the same purpose were so successful that the first ships built at the Government yards on the Atlantic coast have used it, but although it appeared to yield an aggregate lighter in weight than basalt in experimental work, that advantage disappeared when production was made on a commercial scale, and at present it is still possible that basalt may prove equally or more satisfactory where transportation costs are not prohibitive. The curtailment of concrete shipbuilding by the Government after the signing of the armistice leaves it to private enterprise to develop this industry and to determine the relative merits of burned clay and basalt for lightweight aggregate.

MARBLE.

PRODUCTION.

The value of marble sold for building and monumental work since 1896 is shown in figure 113. The outstanding features in this figure are: Until 1914 the general though gradual increase in total value of marble for building, compared with the lack of increase in that for monumental work; since 1914 the marked decrease in value of marble for building contrasted with the increase in value of marble for monumental work, which attained a record in 1918 and exceeded that of building stone for the first time. Another striking feature, expressed in the lower part of the figure is the change in 1913, when the total value of marble for interior building first exceeded that for exterior building.

The marble sold in 1918 amounted to about 3,575,670 cubic feet (approximately 305,720 tons), valued at $5,496,389, a decrease of

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1.4 per cent (52,080 cubic feet, or 4,410 tons) in quantity and of 13.2 per cent ($833,998) in value. In view of the conditions produced

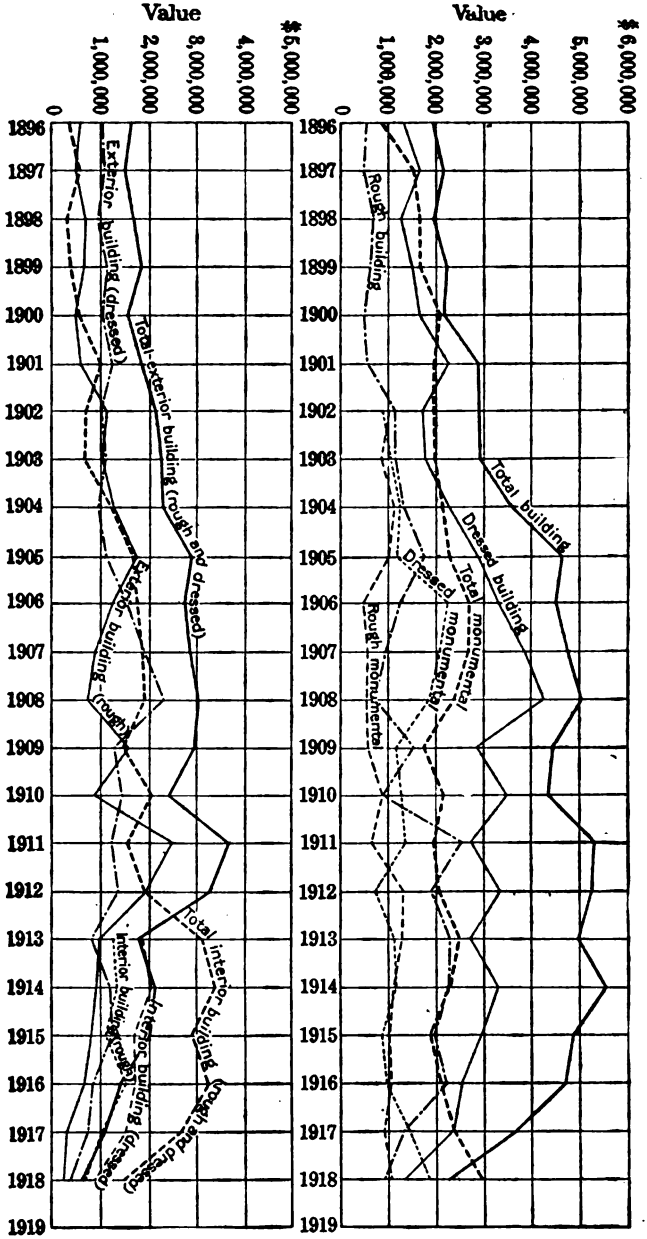

FIGURE 113.—Value of marble sold for building and monumental work, 1896–1918.

in all industries in 1918 by the war the small percentage of decrease in quantity, taken in connection with the larger percentage of decrease in value, would appear anomalous. In 1918, however, less

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than 45 per cent of the total output, 1,594,009 cubic feet, represented high-class building and monumental stone, which decreased 26 per cent (562,342 cubic feet) in quantity and about 15 per cent ($900,730) in value. The average price per cubic foot of this kind of marble in 1917 was $2.83; in 1918 it was $3.26. The remaining 55 per cent of the marble marketed included "waste" stone for furnace flux, paper mills, riprap, and road metal; crushed stone for terrazzo, stucco, and poultry grit; and pulverized stone ("marble flour") for agricultural uses and for use as a filler, mainly in the manufacture of putty, paint, soap, and rubber, and for use at chemical works. The total quantity of stone of these kinds sold in 1918 was 169,432 tons (approximately 1,981,660 cubic feet of solid stone), having a value of $296,839. The marble sold for these purposes in 1917 amounted to 125,764 tons, valued at $230,107, an increase in 1918 of nearly 35 per cent in quantity and of 29 per cent in value. The large increase in the quantity of this class of stone and the smaller increase in its value was due to the larger proportion of low-priced riprap and crushed stone in the output in 1918. The average price in 1917 was $1.83; in 1918 it was $1.75. In 1918 many quarrymen, in order to keep their plants active and in good condition, took advantage of any demand for rough stone and its products which could be supplied from their quarries.

The figures given include a small quantity of "onyx marble" quarried by one firm in California, and a quantity of serpentine, for which details are given on page 1245.

In the conversion of tons to cubic feet, or vice versa, in order to obtain a statement of total output an average weight of 171 pounds for a cubic foot of marble has been assumed, but on account of the diversity in the sizes of blocks sold and the irregularity of their shapes no attempt has been made to allow for waste in sawing or cutting the stone.

PRODUCTION BY USES.

Marble sold in the United States in 1917 and 1918.

	1917			1918		
	Quantity.	Value.	Average price.	Quantity.	Value.	Average price.
Building stone:						
Rough—						
Exterior.....cubic feet..	238,151	$307,120	$1.29	178,090	$274,704	$1.54
Interior.....do....	584,450	1,040,167	1.78	375,651	679,975	1.81
Dressed—						
Exterior.....do....	290,342	779,248	2.68	151,490	394,349	2.60
Interior.....do....	357,850	1,576,038	4.40	174,866	903,234	5.16
Total exterior.....do....	528,493	1,086,368	2.06	329,580	669,053	2.03
Total interior.....do....	942,300	2,616,195	2.78	550,517	1,583,209	2.88
Total building stone.....do....	1,470,793	3,702,563	2.52	880,097	2,252,262	2.56
Monumental stone:						
Rough.....do....	380,714	939,825	2.47	349,823	1,126,259	3.22
Dressed.....do....	304,844	1,457,892	4.78	364,089	1,821,029	5.00
Total monumental stone....do....	685,558	2,397,717	3.50	713,912	2,947,288	4.13
Total building and monumental.....cubic feet..	2,156,351	6,100,280	2.83	1,594,009	5,199,550	3.26
Marble for other uses.....short tons..	125,764	230,107	1.83	169,432	296,839	1.75
Total marble sold: Cubic feet[a]....	3,627,750	6,330,387	1.74	3,575,670	5,496,389	1.54
Short tons[a].....	810,130	.....	20.41	305,720	.....	17.98

[a] Approximately.

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The total marble sold in 1918 for use as building stone was 880,097 cubic feet, valued at $2,252,262, a decrease of 590,696 cubic feet (40 per cent) in quantity and of $1,450,301 (39 per cent) in value. These figures would indicate that the demand in 1918 was supplied either by stone of lower grade or by stone on which less dressing had been done. Marble for exterior building decreased in output 198,913 cubic feet (38 per cent) and its value decreased $417,315 (38 per cent). A little more than half of this exterior marble was sold as rough stone, and this decreased 25 per cent in quantity and 11 per cent in value, while the dressed exterior stone decreased 48 per cent in quantity and 49 per cent in value. Marble for interior building work, representing over 62 per cent of the total building marble, decreased 42 per cent in quantity (391,783 cubic feet) and 39 per cent in value ($1,032,986). Of the marble sold for interior work 68 per cent was sold as rough blocks, and this decreased 36 per cent in quantity and 35 per cent in value in 1918, while the dressed stone sold for interior work decreased 51 per cent in quantity and 43 per cent in value.

Missouri, Georgia, and New York furnished most of the marble for rough exterior work, and Georgia, Vermont, and Missouri more than 80 per cent of dressed exterior marble. More than one-third of the rough marble sold for interior work was from Tennessee, and Missouri and Vermont together produced a little less than Tennessee. Tennessee furnished about one-half the dressed stone for interior work, but the output from Vermont, although about 45 per cent less than that of Tennessee, showed a much larger value.

Though the trade in building marble was affected by labor conditions and by restrictions that hampered all building operations, the trade in monumental marble, which had shown a decrease in quantity and an increase in value in 1917, showed increase in both quantity and value in 1918, and although the quantity did not equal that sold in 1916 the value was 40 per cent higher than in that year.

Ordinarily the output of building marble is more than twice as much as that of the monumental marble, but in 1918 only about one-fourth more was sold. The monumental marble sold in 1918 amounted to 713,912 cubic feet, valued at $2,947,288, an increase of 28,354 cubic feet (4 per cent) in quantity and of $549,571 (23 per cent) in value. The rough monumental stone sold decreased 9 per cent in quantity but increased nearly 20 per cent in value. Dressed monumental stone increased both in quantity (19 per cent) and in value (25 per cent).

Over 75 per cent of the rough monumental marble and about 60 per cent of the dressed stone was furnished by Vermont, and Georgia was the next largest producer.

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The distribution according to uses of marble sold for other purposes than building and monumental work in 1917 and 1918 was as follows:

Marble sold in the United States in 1917 and 1918, by uses.

Use.	1917		1918	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Pulverized marble ("flour")	23,293	$58,631	28,815	$86,619
Terrazzo	12,551	37,468	8,350	39,957
Furnace flux	18,932	15,072	61,613	84,809
Riprap	25,000	12,781	33,722	38,909
Road metal, concrete, etc.	45,988	106,155	15,957	21,655
Other uses			20,975	24,500
	125,764	230,107	169,432	296,839

As may be noted, all products increased in quantity and value except the stone reported as sold for use as terrazzo and for miscellaneous uses, but even that sold for terrazzo increased in value.

Pulverized marble includes material used as a filler in many products, principally paper, putty, paint, rubber, and soap, and a small quantity sold for agricultural uses. The production of this "flour," as it is called in the trade, has increased considerably during the last few years, for the product now takes the place of chalk and whiting. In 1917 besides these uses and, exclusive of limestone for agricultural use, 34,983 short tons of limestone, valued at $75,326, was sold for the manufacture of whiting, and in 1918 43,011 short tons, valued at $196,944, was sold.

Under "other uses" is included marble sold to pulp mills, that sold for the manufacture of artificial stone and carbonic-acid gas, and that sold for other uses not specified.

PRODUCTION BY STATES.

Twenty States reported an output of marble in 1918, one more (South Carolina) than in 1917. The number of operators in 1918 was 64; in 1917 it was 69; and in 1916 it was 80.

Vermont produced 50 per cent, Georgia about 21 per cent, and Tennessee about 11 per cent of the total value in 1918, these three States together thus producing 82 per cent of the total value. In 1917 Vermont produced 48 per cent of the total value, Georgia 17 per cent, and Tennessee 14 per cent, 79 per cent in all. Vermont and Georgia marbles are used extensively in both monumental and building work, but Tennessee marble is in demand principally for use as interior building stone. In many States there are only a few producers, so that it is not possible to show the production by States without revealing individual output. The figures in the table showing production by States, however, are itemized as far as they can be without disclosing confidential reports from producers, and neighboring States are grouped together in order to show the relative importance of the marble industry in different parts of the country. Although increase is shown in only two States (Georgia and Mis-

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souri) that are listed separately, three others (Maryland, Texas, and Washington) also reported increase.

Value of marble sold in the United States, 1914–1918, by States.

State.	1914	1915	1916	1917	1918
Alabama	$370,766	(a)	(a)	(a)	[b] $319,040
Alaska	(a)	(a)	(a)	(a)	[b] 80,059
Arkansas	(a)	(a)	(a)	(a)	(b)
California	70,451	$47,976	$62,397	$109,504	50,776
Colorado	(a)	(a)	(a)	(a)	
Georgia	1,190,742	973,605	903,343	1,073,783	1,152,444
Kentucky	(a)	(a)			
Maryland	(a)	(a)	(c)	(c)	[b] 44,499
Massachusetts	206,883	223,203	154,090	118,808	93,433
Missouri	(a)	122,238	156,942	227,520	238,111
New Mexico	(a)	(a)	(a)	(a)	(b)
New York	248,787	202,843	268,391	249,180	135,756
North Carolina	(a)	(a)	(a)	(a)	[b] 31,779
Oregon		(a)			(b)
Pennsylvania	(a)	60,819	[c] 107,212	[c] 36,442	(b)
South Carolina		(a)	(a)		(b)
Tennessee	1,253,549	959,037	1,000,266	881,634	599,096
Texas	(a)	(a)	(a)	(a)	(b)
Utah	(a)	(a)	(a)	(a)	(b)
Vermont	3,490,971	2,792,764	3,062,743	3,024,315	2,751,396
Virginia	(a)	(a)		(a)	(b)
Washington	(a)		(a)	(a)	(b)
Undistributed	1,289,263	1,533,540	1,317,787	606,151	
	8,121,412	6,916,025	7,033,171	6,330,387	5,496,389

[a] Included in "Undistributed."
[b] Alabama includes Arkansas, New Mexico, and Texas; Alaska includes Oregon, Utah, and Washington; Maryland includes Pennsylvania; North Carolina includes South Carolina and Virginia.
[c] Pennsylvania includes Maryland.

Marble sold in the United States in 1917 and 1918, by States or districts.

State.	1917			1918		
	Quantity.	Value.	Average price.	Quantity.	Value.	Average price.
Alabama, Arkansas, New Mexico, and Texas:						
Cubic feet	120,353	$322,449	$2.68	89,336	$248,754	$2.78
Short tons	30,500	33,935	1.11	48,041	70,286	1.46
		356,384			319,040	
Alaska, Colorado, [a] Oregon, [b] Washington, and Utah:						
Cubic feet	74,685	187,969	2.52	35,773	80,059	2.24
Short tons	300	2,000	6.67			
		189,969			80,059	
California:						
Cubic feet	20,888	49,904	2.39	17,370	48,776	2.81
Short tons	30,090	59,600	1.98	300	2,000	6.67
		109,504			50,776	
Georgia, North Carolina, South Carolina, [b] and Virginia:						
Cubic feet	352,307	1,094,665	3.10	280,793	1,118,339	3.98
Short tons	26,315	38,916	1.48	27,458	65,884	2.40
		1,133,581			1,184,223	
Maryland and Pennsylvania:						
Cubic feet	9,643	25,685	2.66	6,104	18,293	3.00
Short tons	6,275	10,757	1.71	15,309	26,206	1.71
		36,442			44,499	

[a] No production in 1918. [b] No production in 1917.

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Marble sold in the United States in 1917 and 1918, by States or districts—Contd.

State.	1917			1918		
	Quantity.	Value.	Average price.	Quantity.	Value.	Average price.
Massachusetts:						
Cubic feet	46,783	$93,133	$1.99	27,869	$66,070	$2.37
Short tons	14,706	25,675	1.75	13,200	27,363	2.07
	.....	118,808	.....	.....	93,433	.....
Missouri: Cubic feet	204,517	227,520	1.11	196,519	238,111	1.21
New York:						
Cubic feet	88,655	212,982	2.40	42,767	96,088	2.25
Short tons	14,812	36,198	2.44	14,897	39,718	2.66
	.....	249,180	.....	.....	135,756	.....
Tennessee:						
Cubic feet	425,332	883,404	2.08	262,913	582,639	2.22
Short tons	1,066	1,280	1.20	13,995	16,457	1.18
	.....	884,684	.....	.....	599,096	.....
Vermont:						
Cubic feet	813,188	3,002,569	3.69	634,565	2,702,471	4.26
Short tons	1,700	21,746	12.79	36,232	48,925	1.35
	.....	3,024,315	.....	.....	2,751,396	.....
Total: Cubic feet	2,156,351	6,100,280	2.83	1,594,069	5,199,550	3.26
Short tons	125,764	230,107	1.83	169,432	296,839	1.75
	.....	6,330,387	.....	.....	5,496,389	.....
Total marble sold:						
Cubic feet (approximate)	3,627,750	6,330,387	1.74	3,575,670	5,496,389	1.54
Short tons (approximate)	310,130	.....	20.41	305,720	.....	17.98

Alabama.—Alabama, whose output increased 16 per cent in value in 1917, showed a decrease of nearly 10 per cent in 1918, but retained its rank as fourth among the marble-producing States. The quantity of stone sold for building and monumental use in 1918 decreased about 25 per cent, whereas stone sold for other purposes (terrazzo, flux, pulverized marble, and riprap) showed a larger tonnage than in 1917. The two producing localities were, as in 1917, at Gantts Quarry and near Sylacauga, Talladega County. Business conditions were reported as satisfactory in so far as amount of work offered was concerned, but labor conditions limited the output of the quarries. Prices were reported as advanced about 35 per cent over 1917, in order to balance the increased cost of labor and supplies.

Alaska.—Alaska's output was greatly curtailed in 1918, as in 1917, by prohibitive freight rates, scarcity of ships and of labor. The only quarry in operation was that of the Vermont Marble Co., at Tokeen.

Arizona.—It was reported that the Dragoon Marble Mining Co., whose quarry is near Dragoon, Cochise County, Ariz., worked a part of 1918, opening up quarries, making roads, and taking out samples preparatory to shipping marble to Los Angeles in 1919.

Arkansas.—The only marble quarrying in Arkansas in 1918 was at Batesville, Independence County. This stone is sold chiefly as exterior building stone and the cessation of building operations that were not connected with war enterprises, as well as problems of labor and supplies, lessened the output of marble for this State.

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California.—The value of the marketed production of marble in California in 1918 was $50,776, a decrease of 53 per cent. With the exception of a small quantity sold for terrazzo, this stone was all used for interior building work. The stone classified as marble in this State includes serpentine (verde antique) quarried on Catalina Island, Los Angeles County, and "onyx marble" quarried near Tolenas Springs, Solano County, besides the marbles at Columbia and Sonora, Tuolumne County. Labor conditions were a handicap to the quarry operators, but marble from Alaska was hard to get on account of lack of shipping facilities, and eastern marble was off the market on account of high freight rates, so that the local marble had the advantage of whatever building operations there were.

Colorado.—No production or sales were reported from Colorado in 1918. The Colorado-Yule Marble Co., was a large producer until it went into receiver's hands in 1916. This company first reported sales of marble in 1908, and its product has been shipped quite generally throughout the United States. Large quantities have been used in Los Angeles, Calif., and Denver, Colo., for both building (exterior and interior) and monumental work. The statues over the entrance door of the Cuyahoga County Courthouse, Cleveland, Ohio, as well as some of the interior stonework, are of this marble. Probably its most conspicuous monument is the Lincoln Memorial in Potomac Park, Washington, D. C.

The Colorado-Yule Marble Co. has a large well-equipped plant, which, including the quarries, mills, and railroads with their equipment and the immense marble resources available in undeveloped property, is estimated to be worth more than $2,500,000.[18] For several years the company did not pay its Gunnison County taxes, which aggregated $75,000, and when the company was in the hands of a receiver, without funds and unable to raise $35,000, which would have effected a compromise and a settlement, the county commissioners ordered the plant sold for taxes and finally agreed to sell their claim to a Denver junk dealer. This deal, however, was prevented by injunctions from different parties, one of which was accompanied by a substitute offer of $38,000. No decision had been handed down up to the close of 1918. In June, 1918, the company was permitted by the Colorado Public Utilities Commission to close its railroad, which had been damaged by a washout. It is the desire of the receiver to hold the property intact and in good condition in case the revival of building and monumental business may warrant a better disposal of it.

Georgia.—Georgia's marble production in 1918 was marked by an increase of 7 per cent ($78,661) in value. This State ranks second in value in the marble industry, and in 1918 its output represented 17 per cent of the quantity and 11 per cent of the value of all the building and monumental marble produced in the United States. A considerable quantity of stone for flux, agriculture, whiting, stucco, and terrazzo was also sold from the quarries of this State. The producing localities in 1918 were at Tate and Whitestone, Pickens County.

Maryland and Pennsylvania.—Maryland and Pennsylvania together showed an increase in quantity and value of output in 1918. The increase, however, was for the Maryland production only. The demand for exterior and interior building stone was very poor, and

[18] Stone, November, 1918.

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prices were reported as advanced about 30 per cent. Demand for pulverized and crushed marble was good and accounted for the total increase. The producing localities were Cockeysville, Baltimore County, and Cardiff, Harford County, Md. (serpentine), and Easton, Northampton County, Pa. (serpentine).

Massachusetts.—The value of marble quarried in Massachusetts, which in 1917 was lower than for any year since 1901, showed a further decrease (21 per cent) in 1918. The producing localities were Lee and North Adams, Berkshire County, and Westfield, Hampden County (serpentine). Besides the marble used for building and monumental work, a considerable quantity—13,200 tons, valued at $27,363—was used in 1918 for terrazzo, marble "flour," and flux.

Missouri.—The marble marketed in Missouri—196,519 cubic feet, valued at $238,111, in 1918—showed an increase of nearly 5 per cent ($10,591) in value over 1917, but a decrease of 7,998 cubic feet (4 per cent) in quantity. The average price was $1.21 in 1918 and $1.11 in 1917. The marbles of this State are from the Phenix, Greene County, and Carthage, Jasper County, districts. The Carthage stone is also sold as limestone, and a detailed statement of production for 1917 and 1918 is given under limestone on page 1268 of this report.

New York.—The value of the marble produced in New York in 1918 was $135,756, a decrease of 46 per cent. This is the smallest recorded value for marble for this State. The average value of the stone sold for building and monumental purposes was $2.25 per cubic foot in 1918, a decrease of 15 cents a cubic foot. The cessation of practically all building operations in 1918 was the cause of the large decrease, as the marble of this State is primarily a building stone, with New York City as its chief market. The quantity of marble sold for other than building and monumental work was 14,797 short tons, practically the same as in 1917, but the value ($39,718) increased about 10 per cent. The average value per short ton was $2.44 in 1917 and $2.68 in 1918. This stone is sold as pulverized marble or "flour" for agricultural purposes, for paint and soap filler, for riprap, flux, and the manufacture of artificial stone.

In 1918 the active quarries were at Bluff Point, Clinton County, for interior building marble; Wingdale, Dutchess County, for exterior building stone; Gouverneur, St. Lawrence County, for monumental and exterior building stone as well as stone for flux and riprap; Glens Falls, Warren County, for stone for exterior building, and Tuckahoe, Westchester County for stone for terrazzo, agricultural use, soap filler, stucco, and for the manufacture of artificial stone.

North Carolina.—Because of shortage of labor and fuel, the marble quarries at Regal, Cherokee County, N. C., were operated only part of the year with a consequent decrease in quantity, although the average price per cubic foot increased. This stone is used almost entirely for monumental work.

Tennessee.—The marble quarries of Tennessee, which furnish marble chiefly for interior building work, have seemingly been more seriously affected by the war conditions than the other large marble districts. The value of the marble produced in Tennessee in 1918, $599,096, was the lowest since 1905 ($582,229). The total value for 1918 decreased $285,588 (32 per cent) and followed a decrease in 1917 of $115,582 (11.5 per cent). The marble sold for building and

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monumental stone in 1918 amounted to 262,913 cubic feet, valued at $582,639, a decrease of 162,419 cubic feet (38 per cent) in quantity and $300,765 (34 per cent) in value. The average value per cubic foot increased from $2.08 in 1917 to $2.22 in 1918. The considerable decrease in quantity reduced Tennessee to third in rank of the marble-producing States in both quantity and value of output.

The quarrymen stated that war conditions made it impossible to obtain enough labor for the quarries; hence production was necessarily so reduced that it was difficult to quarry enough blocks to keep the mills running for filling orders on hand. Unforeseen increases in cost of production and manufacture in the quarries and mills were stated to have caused losses on orders already taken and to have made 1918 the worst year ever experienced in the Tennessee marble industry.

The crushed and pulverized stone sold in 1918 showed a considerable increase, but the average value per short ton ($1.18) was slightly less than in 1917. A quantity of waste limestone is sold annually to manufacturers of lime and the value of this stone is not included in the total.

Tennessee marble is well known to the trade by its different shades of pink, gray, and brown. The present domestic output of black marble is from Vermont and Virginia, but a deposit containing black, green, gray, and blue marble was opened in Tennessee in Gin Hollow, 2½ miles northeast of Flintville station on the North Carolina & St. Louis Railroad, Lincoln County, by the Brighton Marble & Development Co. in 1917. The deposit is 2 miles from the railroad and inability to get a spur track connection is given as the reason that no marble was shipped in that year or in 1918. The varieties of stone and their respective thicknesses, according to a report by R. H. Elliott, are as follows:

	Feet.
1. Green marble ("seafoam-green") with nodules of flint or chert	20
2. Black shale	5
3. Gray marble ("Confederate gray")	10
4. Green marble ("autumn-leaf green")	20
5. Black marble ("duro black")	42
6. Steel-gray marble	5
7. "Bird's-eye antique" marble	25
8. Blue marble ("of doubtful quality")	40

In one section bronze-colored marble, and in another pink marble is present instead of the "autumn-leaf green." All the strata in the foregoing section are above water level, and self-draining quarries may be opened in the slopes. The marble is said to work easily. Partial chemical analyses are as follows:

Analyses of marble near Flintville station, Tenn.

	1	3	4	5	7	8
Silica (SiO_2)	28.29	1.27	1.01	1.27	5.17	12.37
Alumina (Al_2O_3)	.17	.08	.05	.33	.83	1.05
Magnesium carbonate ($MgCO_3$)	26.23	.38	.13	.65	.54	.57
Calcium carbonate ($CaCO_3$)	40.85	96.92	98.85	97.07	91.57	83.82
Phosphorus pentoxide (P_2O_5)	.12					.07
	95.66	98.65	100.04	99.32	98.11	97.88

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Analyses 3, 4, and 5 indicate that waste stone from these beds may be suitable for several chemical uses which require a high grade of high calcium lime or limestone.

Texas.—The marble quarry at San Saba, Tex., was in operation in 1918 with practically the same output as in 1917.

Utah.—The only commercial marble operations in Utah in 1918 were at the quarry near Thistle Mountain in Utah County. The entire output was sold for interior building work.

Vermont.—Vermont's production represented 50 per cent of the total value of the marble quarried in the United States in 1918, and nearly 40 per cent of the quantity and 52 per cent of the value of the building and monumental marble sold. In both quantity and value of production Vermont continues to outrank all other States by a wide margin.

The total sales of marble in the State decreased 9 per cent in value in 1918. Excluding a quantity of stone sold for terrazzo, furnace flux, and to paper mills, the marble marketed decreased 197,973 cubic feet (24 per cent) in quantity and $321,844 (11 per cent) in value. The average price per cubic foot was $3.63 in 1917 and $4.26 in 1918. The details by uses of the Vermont marble production are shown in the following table:

Marble sold in Vermont in 1917 and 1918.

Use.	1917			1918		
	Quantity.	Value.	Average price.	Quantity.	Value.	Average price.
Building:						
Rough, exterior.....cubic feet..	40,791	$44,828	$1.10	(a)	(a)	(a)
Dressed, exterior.....do....	179,906	438,945	2.44	a 63,261	a $161,826	a $2.56
	220,697	483,773	2.19	63,261	161,826	2.56
Rough, interior.....do....	119,123	328,224	2.76	48,429	128,528	2.65
Dressed, interior.....do....	95,950	699,800	7.29	39,173	344,728	8.80
	215,073	1,028,024	4.78	87,602	473,256	5.40
Total building.....do....	435,770	1,511,797	3.47	150,863	635,082	4.21
Monumental:						
Rough.....do....	217,988	611,976	2.81	265,436	872,657	3.29
Dressed.....do....	159,430	878,796	5.51	218,266	1,194,732	5.47
	377,418	1,490,772	3.95	483,702	2,067,389	4.27
Building and monumental.....do....	813,188	3,002,569	3.69	634,565	2,702,471	4.26
Other.....short tons..	1,700	21,746	12.79	36,232	48,925	1.35
	.....	3,024,315	.....	.....	2,751,396	.....

a Rough exterior included in dressed exterior.

The stone sold for building, rough and dressed, decreased 284,907 cubic feet (65 per cent) in quantity and $876,815 (about 58 per cent) in value.

The stone sold for monumental work, rough and dressed, in 1918, increased 106,284 cubic feet (28 per cent) in quantity and $575,617 (38 per cent) in value, not enough in either quantity or value to offset the decrease in building stone.

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The marble marketed in Vermont in 1918 was from Middlebury, Addison County (rough interior building stone and terrazzo); East Dorset, Bennington County (rough interior building stone); Swanton, Franklin County (dressed interior building stone); Brandon, Clarendon Springs, Danby, Pittsford, Proctor, Rutland, and West Rutland, Rutland County (rough and dressed interior, rough and dressed monumental, rough and dressed exterior, flux, terrazzo, and paper mills); and Roxbury, Washington County (serpentine, for rough interior and rough and dressed exterior building).

Virginia.—The black marble quarries at Harrisonburg, Va., were idle in 1918, owing to labor difficulties and railroad restrictions. Some of the stone on hand, however, was sold during 1918.

Other States.—Small quantities of marble were quarried for local consumption at Alamogordo, N. Mex., Williams, Oreg., Oconee, S. C., and Chewelah, Stevens County, Wash. No production was reported from the quarry of the Michigan Verde Antique Marble Co. near Ishpeming, Mich., but some progress was made on the construction of the spur track to the quarry.

SERPENTINE (VERDE ANTIQUE).

The serpentine represented in the table below is that variety which is used as building or ornamental stone and is known commercially as green marble or verde antique.

No serpentine was sold rough for use as exterior building stone either in 1917 or in 1918. The output in 1918 was valued at $135,138, which was $59,778 less than in 1917. Sales in 1917 and 1918 were reported from Vermont, Pennsylvania, Massachusetts, California, and Maryland, the States being here named according to value of output, one producer reporting from each State.

Serpentine (verde antique) sold in the United States in 1917 and 1918.

	1917		1918	
	Quantity.	Value.	Quantity.	Value.
Cubic feet	35,371	$179,085	19,154	$117,632
Square feet	8,064	10,424	.....	.....
Short tons	1,815	5,407	9,509	17,506
	.....	194,916	.....	135,138

NOTES ON FOREIGN MARBLES.

Statements of American consuls published in commerce reports and statements given in trade journals on the conditions of the marble industry in different countries have been abstracted and are given below as being of particular interest to the domestic marble industry at the present time.

In the following notes on foreign marbles mention is made of only such marbles as have been called to the attention of the writers either on account of recent development or because their output has a direct effect on the marble industry of the United States.

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ITALY.

The publication Stone[14] quotes the Italian journal L'Industria to the effect that there was a decrease of nearly 8 per cent in the value of the stone produced in Italy in 1916.

This decrease was said to be caused principally by the decreased output of white and colored marbles, which in 1915 began to undergo great decrease on account of scarcity of labor, stagnation of commerce, increased cost of raw materials, and great rise in freight rates for foreign countries, which imported nearly all the worked marble. In 1916 the production of rough and worked marble in Italy fell from 246,883 to 200,700 (metric) tons. This decrease was partly due to the quarries of the Apuan Alps, which produced only 171,865 tons in 1916 compared with 199,724 tons in 1915. The output of the Veronese and Vicentino quarries fell from 9,776 and 11,150 tons in 1915 to 3,250 and 5,126 tons, respectively, in 1916. Of the total rough marble quarried 122,732 tons was worked, 98,660 tons in sawmills and 24,072 in workshops. The rough marble remaining represented 49,133 tons. Exports from Italy, which as in the past consisted of superior qualities of marble principally sawed rather than rough, showed a decrease of 13,451 tons in 1916, although there was some increase in exports to France, Switzerland, and the United States. The number of workmen at the Apuan quarries in 1916 was 5,077, compared with 6,960 in 1915, the number of workings remaining about the same—173 instead of 174. The cost per ton of marble quarried decreased from 22.93 to 19.73 lire, while the yield per workman increased from 28.7 tons in 1915 to 33.71 in 1916.

The same journal[15] publishes the following figures which indicate the extent of the decrease in the quantity (metric tons) of marble shipments from Carrara and Massa, important marble centers of Italy, from 1913 to 1917—Carrara, 1913, 245,600 tons; 1914, 207,001 tons; 1915, 110,850 tons; 1916, 101,015 tons; 1917, 69,017 tons; Massa, 1913, 51,250 tons; 1914, 44,118 tons; 1915, 25,120 tons; 1916, 13,722 tons; 1917, 9,131 tons.

According to a report of the United States Consul at Genoa, Italy,[16] an official decree published May 2, 1917, provided that a portion of the proceeds of a tax levied on marble quarried within the limits of Carrara might be used in meeting the expenses of constructing and operating the port of Carrara. It stipulated, however, that the city must contribute not less than one-fourth of the gross proceeds of this tax to the marble workers' relief fund.

Marble quarrying at Carrara was at a standstill, owing to shortage of labor, fuel, and transportation facilities.[17] Marble, furthermore, was on the embargo list of most countries. After the armistice was declared, the workmen asked and received a further increase in wages and had the length of their working day reduced to eight hours. These changes have caused a further increase in selling price of marble, though less in proportion than the increase in costs. Increase in local transportation charges is likely to raise prices still more. Stocks of marble have become greatly depleted and together

[14] Stone, December, 1918.
[15] Stone, September, 1918, p. 419.
[16] Commerce Repts., June 11, 1917.
[17] Stone, May, 1919, p. 211.

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with continued shortage of labor and transportation facilities are likely to curtail export trade for some time.

FRANCE.

The exportation and reexportation of marble intended for England, the uninvaded part of Belgium, Italy, and countries outside of Europe without special authorization were permitted by the French minister of finance, October 7, 1918, according to the American consul general.[18]

BELGIUM.

It is stated[19] that the black marble quarries of Belgium, which prior to the war shipped their product to all parts of the world, were used by the Germans as emplacements for their large guns and that the marble immediately beneath the guns was so badly shattered that the quarries will be useless for the production of marble for building and monumental work without the expense of removing a large quantity of waste stone and rehabilitating them.

Belgium[20] had some of the largest and best equipped quarries in the world. That country had specialized in stoneworking machinery and especially in the application of electricity to the quarrying and working of stone. It is reasonably certain that Germany requisitioned the greater part of this equipment.

SPAIN.

Concerning black marble the American consul at Santander, Spain,[21] says that this Province possesses valuable marble quarries of which the King Alfonso quarry, better known as "Flanders granite," produces black marble and the Queen Victoria quarry produces marble of different colors, the veiny kind being specially abundant. The deposits of both kinds of marble are of considerable extent.

SPITZBERGEN.

Considerable interest was revived recently, according to the Building World,[22] in deposits of colored ornamental and building marble on Marble Island, one of the Spitzbergen Islands lying to the north of Norway. The deposits which contain marble of wide range of color and rich contrasts were said to be very accessibly located for transportation on the least icebound bay of Spitzbergen, where it would be possible to ship marble during the greater part of the year. The Northern Exploration Co., 62 London Wall, London, England, had the enterprise in charge, and it was reported that the deposits would be worked immediately, but according to more recent information the deposits are too much fractured and the stone too friable for architectural purposes.[23]

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[18] Stone, November, 1918, p. 320.
[19] Am. Stone Trade, May 1, 1918.
[20] From an article quoted in Stone, October, 1918, p. 460, and in The Monument Reporter, November, 1918, p. 13.
[21] Stone, December, 1918, p. 559.
[22] Building World, London, England, Apr. 5, 1919, p. 492.
[23] Letters by Rolf Marstrander and R. H. Blumenthal, Mining Mag. (London), vol. 21, No. 1, p. 40, July, 1919.

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These statements were opposed by an official of the company, who maintained that large blocks of sound stone were to be found at shallow depth, as shown by borings.[24] It remains to be seen, therefore, whether development work proceeds to the producing stage.

Some exploration work, in which American machinery was used, was done on these deposits six or seven years ago, and a brief account of them was published in 1913.[25]

MEXICO.

The principal producing locality in Mexico is in Lower California, but a deposit near Salina Cruz is reported by the American consul[26] as in the mountainous portion of the Tehuantepec River valley, along the Toquisistlan, a tributary stream, where several valuable fields are known to exist. The developed quarries are 4 miles from Toquisistlan and 33 miles from Tehuantepec, the nearest railway station. These have been worked for a considerable period, and in the four or five years preceding 1910 some 30,000 cubic feet of onyx was quarried and exported to the United States. No onyx is at present being brought out of the fields, as this territory is dominated by brigands. Transportation is the principal obstacle to the successful development of these fields, as up to the present all onyx exported has been hauled to Tehuantepec. The onyx in this field is largely of the white and pink varieties, some of the remainder being beautifully mottled. It is said to be superior to that of Lower California, bringing $7.50 a cubic foot delivered on shipboard at Boston, Mass., whereas the Lower California onyx sells at $5 a cubic foot. The size obtainable is limited only by transportation facilities. With the present facilities it is not possible to bring out slabs larger than 3 by 6 feet, and 6 inches thick.

CUBA.

Exploitation and development work on marble deposits located on the Isle of Pines, Cuba, has been carried on from time to time, and the consul general at Nueva Gerona in a report dated March 24, 1919, states that a deposit of marble of remarkable fineness and beauty of color, located near Nueva Gerona, is being put in condition for commercial use. The marble, which is white, is being taken out in large blocks and will be cut and polished at the quarry in order to reduce the cost of transportation. Some of the machinery for this work has already arrived from the United States and is being erected under American supervision. The marble is expected to find a market in both Havana and in the United States.

GREECE.

The consul general[27] at Athens, Greece, states that the quarrying of marble in Greece in the last few years has practically ceased and that the English company which controlled most of the quarries has

[24] Mansfield, Ernest, Mining Mag. (London), vol. 21, No. 2, p. 96, August, 1919.
[25] Stone, May, 1913, pp. 241–242. Quoted in part from the Stone Trades' Journal, London.
[26] Commerce Repts, Jan. 30, 1919, p. 452.
[27] Monthly report on commerce and industries, February, 1919.

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sold the greater part of the machinery and proposes to work the quarries in a more primitive manner on account of the cheapness of labor.

In a later report [28] the production of marble in Greece in 1916, 1917, and 1918 is given as follows:

Marble produced in Greece, 1916–1918.

	Produced (metric tons).	Sold.		
		Metric tons.	Value.	Average price per ton.
1916	341	251	$13,057	$52.02
1917	173	390	22,059	56.50
1918	297	1,740	.....	.....

It is inferred that sales in 1917 and 1918 were made from stock on hand. It is further stated that practically the only firm exporting marble from Greece—the Grecian Marbles (Marmor) (Ltd.)—reports that it was unable to ship any marble in 1919, owing to freight rates and import and export restrictions. The operations of this company are described by the consul as follows:

Owing to transport and shipping difficulties the colored-marble quarries at Larissa and on the islands of Tinos, Skyros, and Syra were not worked during the year (1918). The Pentelic quarries were worked for a few months to supply marble for local orders, the total amount extracted being 297 tons. Practically the whole stock on hand from previous years was sold to Greek merchants and contractors in Attica. Total sales amounted to 1,740 tons in 1918, compared with 1,196 [29] tons sold in 1917. Local business was fairly good during the year and there are good reasons to believe that there will be a large expansion in building operations as soon as conditions improve and construction materials become again accessible.

No marble was shipped to the United States or to England, although there was a great demand in both countries therefor. Even now, prospects for marble shipments are none too bright. As an illustration of this it may be mentioned that this firm has had, since 1916, some 300 tons of marble lying on the docks at Piraeus awaiting shipment to New York. Tentative arrangements were in 1919 made from New York for shipping this consignment to America on an American vessel at $7.50 per ton freight. but upon the approach of the steamer its Piraeus agents demanded a minimum-freight payment of $125 per ton. This, with other expenses, makes the freight cost so much greater than the value of the commodity that it is feared that a long time must elapse before marble can be profitably shipped from Greece.

The following statement illustrates the production of marble and sales during 1918:

	Volume (cubic meters).	Weight (tons).
White Pentelic marble (quantity produced)	99	297
Sales in Greece:		
White and blue Pentelic	503	1,509
Mani (red)	43	129
Tinos (green)	3	9
Syra	11	33
Skyros	20	60
Total sales	580	1,740

[28] Annual report on commerce and industries for 1918 for the Kingdom of Greece, June 16, 1919.

[29] Figures not in agreement with table above.

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GUATEMALA.

In 1916 a considerable quantity of marble was entered at the customs district of New York[80] for immediate consumption from Guatemala, although the general imports for that year did not show this material. The producing locality is near the village San Rosalia, in the hills northwest of Zacapa.

It is stated[81] by W. M. Strachan, trade commissioner, that the marble obtained from this quarry is pure white, and that the deposit is connected with the International Railways by a branch 10 miles long, which gives access to both the Caribbean Sea and the Pacific Ocean. The quarry is operated under concessions which provide for free entrance of machinery and no export tax on marble. In return the company gives the Government 10 per cent of any dividends declared. The railroad has given the quarry company a special rate for 50 years. In 1918 a considerable quantity of marble awaited shipment, but ocean rates were prohibitive. Before the war the United Fruit Co. quoted a rate of $5 a ton to New Orleans, New York, or Boston. The Mallory line and the Wood line gave a very low rate of $2.50 a ton, as the boats brought down coal for the railroad, and were glad to have the stone as return cargo. The railroad is now burning oil over its entire length, and this method of cheap transportation is cut off. The marble is used locally, the natives hewing out the stone and making tombstones and slabs for washboards.

PRICES OF FOREIGN MARBLES.

The following statement, published in the June, 1919, numbers of both the Monument Reporter and Stone, indicates the extent to which the prices of foreign marbles sold in the United States were affected during the war:

The lack of shipping during the war, the embargo on many lines of imports, and the shortage of labor in the European quarries naturally reduced the stock of foreign marbles held in this country. It gave an opportunity for the architects to become more familiar with the admirable decorative marbles that are found in this country, but unfortunately the suspension of building activity caused a moderate demand only. Dow's Daily Service Reports take up the question of foreign marbles. The building pulse, says a recent report, is being reflected by the movement for decorative interior materials. Various authorities have various views on price trends, particularly on foreign marbles. Current stocks are unquestionably low, but there are now on the ocean fine Italian and Belgian marbles, sufficient to keep the market well supplied, according to C. D. Jackson, of C. D. Jackson & Co., who says they are selling black and gold Italian marble as low as $6.70 for firsts, $6 for seconds, and thirds for $5.50.

The highest authorities on the marble situation show, however, that these advances have been made in marble prices since the time that war began to affect the Italian marble quarries, and that the marble situation here is undergoing the same transition with regard to price trend as are other building materials and commodities. White-veined Italian marble, familiar to commerce, has advanced 120 per cent; black and gold, 100 per cent on both first and inferior qualities; Blanco P, 100 per cent; Paonazzetto, 100 per cent; Botticino, 115 per cent; Travertine, 100 per cent; and Travernelle, 120 per cent. These advances were effective when there was scarcely any demand for interior marble in this country. To-day, with demand constantly increasing, the price trend will be toward the higher level, especially since Italian labor costs also

[80] U. S. Geol. Survey Mineral Resources, 1916, pt. 2, pp. 1009–1010, 1919.
[81] Stone, March, 1919.

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have been advanced, and that the effort is to keep prices stable as long as it is possible to do so.

Labor on marble work offsets these price advantages, for in this section of the country the labor wage advances to marble workers have not exceeded 60 per cent.

LIMESTONE.

GENERAL STATISTICS.

The value of the limestone produced in the United States in 1918 increased $3,189,627 (nearly 7 per cent), but the quantity decreased 9,613,300 short tons (15 per cent). The total output for 1918 was 53,868,200 short tons, valued at $49,453,006, and represented 79 per cent of the quantity and 60 per cent of the value of all stone quarried in the United States in that year. The average price was 92 cents a short ton in 1918, which was 19 cents more than in 1917 and 31 cents more than in 1916.

PRODUCTION BY STATES.

Forty-five States produced limestone in 1918. Hawaii, reporting limestone sold to sugar factories, was added to the 1917 list.

Of the total producing States, 23 increased in value of output—Mississippi and Nevada, which reported production of limestone for the first time in 1917, showed increases of 20 per cent and 203 per cent, respectively, in 1918. Mississippi's output was for agriculture and that of Nevada for flux and for sugar manufacture. Maine, selling a small quantity of limestone to paper mills, also showed a considerable increase in value of output. The other States that increased in value of output reported gains ranging from 0.8 per cent in California to 63 per cent in New Jersey, New Jersey's stone being sold principally for flux. Michigan, Pennsylvania, and Ohio each showed increase in value of over $1,500,000. The principal increase in Michigan was for flux, which increased in quantity and value. In Ohio flux and crushed stone increased in value but decreased in quantity. In Pennsylvania flux showed large increase in value but decrease in quantity. For Alabama, Arizona, Colorado, Georgia, Massachusetts, Michigan, New Jersey, New York, Ohio, Pennsylvania, Tennessee, Vermont, Washington, West Virginia, and Wyoming the figures for value represent record values although not in all cases record production.

The decreased output shown by the remaining States ranged from 3 per cent to 83 per cent, and with the exception of the large decrease in the output of building stone in Indiana, the decrease was accounted for in greater part by the decrease in the production of crushed stone.

There were 11 States whose value of output was in excess of $1,000,000 in 1918. States whose product was valued at more than $2,000,000 were, named in order of rank, Pennsylvania, Ohio, Michigan, New York, Illinois, and Indiana. In 1917 Michigan ranked fifth and Indiana third and Illinois sixth. Michigan, Ohio, Pennsylvania, and New York showed gains, respectively, of 56 per cent, 29 per cent, 16 per cent, and 11.5 per cent; whereas, Illinois and

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Indiana showed losses of 10 per cent and 37 per cent, respectively. The total number of active operators in 1918 was 1,190, a decrease of nearly 30 per cent in two years. Most of the small quarries were closed.

Value of limestone sold in the United States, 1914–1918.

State.	1914	1915	1916	1917	1918
Alabama	$787,214	$426,266	$917,559	$1,278,908	$1,370,667
Arizona	(a)	9,800	98,877	140,674	150,850
Arkansas	47,390	32,917	64,809	84,654	89,640
California	296,273	338,179	277,521	364,066	366,826
Colorado	340,059	337,899	406,974	532,539	570,649
Connecticut	(a)	26,246	(a)	(a)	(a)
Florida	343,779	354,673	479,837	494,568	256,807
Georgia	89,216	86,254	82,799	155,172	192,515
Hawaii		(a)	(a)		(a)
Idaho	28,032	(a)	27,721	37,942	21,377
Illinois	2,861,340	2,864,103	3,362,751	3,279,737	2,951,045
Indiana	4,115,557	4,204,092	4,657,813	4,449,809	2,819,063
Iowa	537,362	535,656	561,015	519,933	379,029
Kansas	598,302	535,240	599,995	673,706	561,012
Kentucky	1,196,046	993,388	1,315,702	1,022,317	932,667
Louisiana	(a)	(a)	(a)	(a)	(a)
Maine	(a)			(a)	(a)
Maryland	204,276	180,723	223,182	307,679	274,907
Massachusetts	(a)	(a)	(a)	68,392	92,804
Michigan	1,457,961	1,828,766	2,389,763	3,320,895	5,186,867
Minnesota	489,849	395,763	467,942	385,728	310,583
Mississippi				(a)	(a)
Missouri	2,160,958	1,927,534	1,990,419	1,679,677	1,359,755
Montana	207,821	228,637	237,923	224,986	246,650
Nebraska	302,862	320,341	405,867	475,507	314,280
Nevada				31,625	95,821
New Jersey	240,937	159,549	245,019	413,477	674,397
New Mexico		(a)	(a)	(a)	(a)
New York	3,158,617	3,018,871	3,035,786	3,513,874	3,918,982
North Carolina	58,754	82,672	75,418	109,719	58,055
Ohio	4,131,917	4,405,590	5,337,085	5,400,578	6,960,205
Oklahoma	237,044	398,636	516,230	575,165	574,795
Oregon	(a)	(a)	(a)	4,939	(a)
Pennsylvania	5,270,458	6,367,446	8,167,639	10,589,524	12,302,255
Rhode Island	(a)	(a)	(a)	(a)	(a)
South Carolina		(a)			
South Dakota	12,488	17,485	19,435	46,130	18,825
Tennessee	678,068	855,245	752,649	750,639	893,763
Texas	549,567	492,255	459,918	485,389	464,061
Utah	303,081	196,271	249,998	242,707	341,804
Vermont	24,049	49,405	68,098	45,869	64,847
Virginia	1,194,261	1,534,545	1,062,247	1,263,284	1,230,412
Washington	10,008	11,550	30,338	59,529	99,992
West Virginia	778,749	922,766	1,452,393	1,788,528	1,958,785
Wisconsin	1,007,106	894,158	1,089,111	1,172,567	1,065,678
Wyoming	50,500	(a)	(a)	130,497	155,792
Undistributed	134,254	196,945	179,766	142,450	126,524
	33,894,155	35,229,866	41,309,599	46,263,379	49,453,006

a Included in "Undistributed."

PRODUCTION BY USES.

The table on page 1253 shows the production of limestone in 1917 and 1918 according to uses, and Plate XV illustrates the changes in sales of the principal products of limestone since 1898. In the table the quantities are given in the customary units used in the trade, and also in approximate short tons for purposes of comparison and for expressing the entire quantity.

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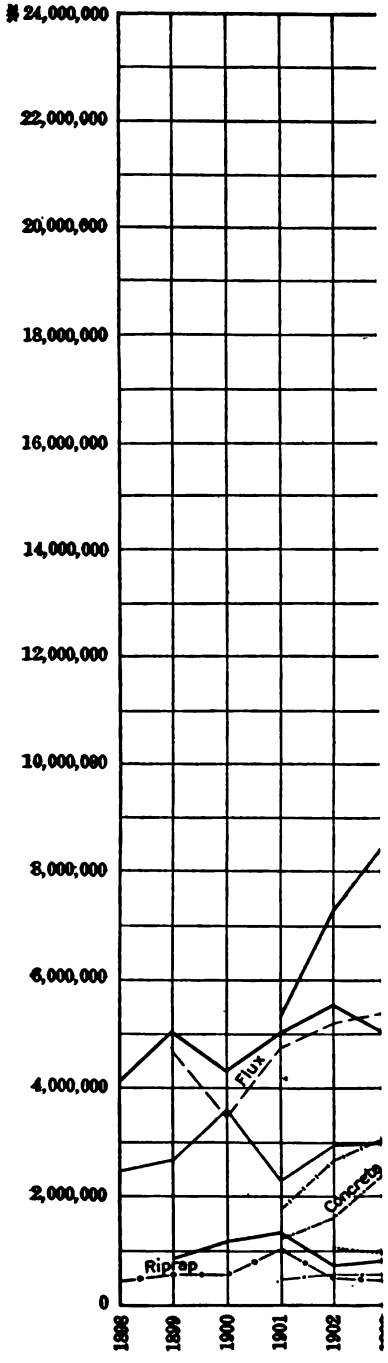

VALUE OF LIMEST

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Limestone sold in the United States in 1917 and 1918, by uses.

Use.	1917		1918	
	Quantity.	Value.	Quantity.	Value.
Building stone.....cubic feet..	[a] 8,481,510	$4,115,366	3,698,035	$2,266,654
Approximate equivalent in short tons.....	712,130	.....	310,640	.....
Paving blocks.....number..	[a] 138,720	7,273	(b)	(b)
Approximate equivalent in short tons.....	1,400	.....	.....	.....
Curbing.....cubic feet..	[a] 78,571	51,972	[b] 37,698	[b] 37,836
Approximate equivalent in short tons.....	6,600	.....	[b] 3,170	.....
Flagging.....cubic feet..	[a] 20,238	8,327	(b)	(b)
Approximate equivalent in short tons.....	1,700	.....	.....	.....
Rubble.....short tons..	277,376	270,327	106,327	109,369
Riprap.....do....	1,007,357	854,884	1,118,109	969,276
Crushed stone.....do....	26,646,642	17,541,098	19,120,858	16,273,184
Fluxing stone.....long tons..	25,574,146	18,679,213	23,862,029	23,427,736
Equivalent in short tons.....	28,643,044	.....	26,725,472	.....
Alkali works.....short tons..	3,124,026	1,417,898	3,437,066	2,263,821
Sugar factories.....do....	530,612	666,138	435,555	649,589
Glassworks.....do....	293,152	344,479	202,211	332,744
Paper mills.....do....	101,305	95,582	100,247	117,829
Agriculture.....do....	1,040,248	1,352,397	1,091,918	1,626,292
Other uses [c].....do....	1,095,952	858,425	1,216,633	1,378,676
Total (quantities approximate, in short tons)..	63,481,500	46,263,379	53,868,200	49,453,006

[a] Partly estimated.
[b] Paving blocks and flagging included in curbing.
[c] Includes stone sold as a filler for asphalt, paint, rubber, soap, and other material; stone sold for the manufacture of basic magnesium carbonate; stone sold to alcohol works and calcium carbide works; dolomite sold for use in making refractory products; stone sold for chicken grit and other products.

The production of limestone for riprap, agriculture, and for use in alkali works and a few other industrial and manufacturing uses increased in both quantity and value in 1918, but the increase in quantity for these purposes was not sufficient to offset the large decrease in building, rubble, crushed stone, and flux, although the increase in the price of all products brought the total value up to an amount greater than the value in 1917. In the following tables, showing the value of limestone by States and uses in 1917 and 1918, the quantity and value is given for all products in 1918, and such quantities as are available have been added to the figures of value for 1917 as published in the report for that year.

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Limestone sold in the United States in 1917, by uses.

State.	Rough building.	Dressed building.	Paving and flagging.	Curbing.	Rubble.		Riprap.	
					Quantity (short tons).	Value.	Quantity (short tons).	Value.
Alabama	(a)				(a)	(a)	8,307	$4,052
Arizona							(a)	(a)
Arkansas					(a)	(a)	8,034	3,056
California	(a)							
Colorado			(a)		(a)	(a)		
Connecticut								
Florida	(a)	(a)						
Georgia								
Idaho					(a)	(a)		
Illinois	$7,128	(a)			70,291	$67,052	217,669	148,314
Indiana	1,633,731	$1,640,872	$6,400	$33,980	4,275	4,402	48,274	23,373
Iowa	12,601	(a)	(a)	(a)	5,209	5,226	63,322	34,772
Kansas	12,469	2,160			4,719	3,135	48,674	27,536
Kentucky	112,247			1,328	4,738	6,648	33,338	25,513
Louisiana							(a)	(a)
Maine								
Maryland	2,599							
Massachusetts								
Michigan	(a)				(a)	(a)	(a)	(a)
Minnesota	18,461	96,474			12,980	10,070	18,267	17,904
Mississippi								
Missouri	72,465	169,582	1,512	(a)	74,199	83,467	156,409	266,829
Montana	(a)		(a)		(a)	(a)	(a)	(a)
Nebraska					(a)	(a)	97,158	63,560
Nevada								
New Jersey								
New Mexico							(a)	(a)
New York	35,305	4,850			747	494	44,150	32,956
North Carolina								
Ohio	11,220	(a)			4,538	6,363	13,988	16,549
Oklahoma		2,250			965	871	9,722	4,939
Oregon								
Pennsylvania	54,207	(a)			(a)	(a)	4,989	3,137
Rhode Island								
South Dakota							(a)	(a)
Tennessee	2,106	(a)			(a)	(a)	39,927	31,781
Texas	21,660			(a)	(a)	(a)	9,940	5,208
Utah	(a)						(a)	(a)
Vermont					(a)	(a)		
Virginia	(a)				(a)	(a)	(a)	(a)
Washington								
West Virginia								
Wisconsin	15,230	250	5,215	15,212	87,599	77,285	114,682	75,231
Wyoming								
Undistributed	72,431	115,042	2,473	1,452	7,116	5,311	70,507	49,674
	2,083,886	2,031,480	15,600	51,972	277,376	270,327	1,007,357	854,884

(a) Included in "Undistributed."

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Limestone sold in the United States in 1917, by uses—Continued.

State.	Flux.		Road metal.		Railroad ballast.		Concrete.	
	Quantity (long tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Alabama	1,157,818	$1,159,035	11,400	$14,170			75,502	$54,368
Arizona	152,877	111,329					(a)	(a)
Arkansas	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
California	68,015	84,414	(a)	(a)	(a)	(a)	16,564	34,704
Colorado	549,852	387,184						
Connecticut	(a)	(a)	(a)	(a)				
Florida			213,697	135,161	141,461	$84,580	57,811	83,517
Georgia	6,385	7,244	(a)	(a)			(a)	(a)
Idaho	(a)	(a)						
Illinois	991,879	434,447	1,095,616	631,869	745,901	342,224	2,626,922	1,494,237
Indiana	324,741	158,476	1,136,653	684,289	262,647	115,721	78,641	50,654
Iowa	18,563	18,895	43,262	44,744	8,529	5,771	499,221	339,622
Kansas	(a)	(a)	165,861	125,057	213,645	137,274	298,804	292,202
Kentucky	54,922	44,826	500,185	366,887	701,438	338,996	163,362	95,537
Louisiana					(a)	(a)	(a)	(a)
Maine								
Maryland	168,532	107,156	116,253	139,734	14,174	12,165	44,870	45,915
Massachusetts	(a)	(a)						
Michigan	3,575,178	1,633,965	726,937	344,970	182,375	90,560	418,403	244,648
Minnesota	(a)	(a)	14,624	12,062	(a)	(a)	222,513	195,108
Mississippi								
Missouri	63,028	71,148	240,322	198,419	170,362	102,906	626,295	605,734
Montana	424,819	183,538	(a)	(a)	(a)	(a)	39,004	27,440
Nebraska	(a)	(a)	34,398	24,886	23,339	18,292	324,504	348,173
Nevada	(a)	(a)			(a)	(a)		
New Jersey	368,850	327,226	19,242	20,379			7,214	9,128
New Mexico					(a)	(a)	(a)	(a)
New York	578,748	426,858	1,224,139	796,013	742,985	472,908	1,367,853	1,012,315
North Carolina	(a)	(a)	(a)	(a)			11,658	10,631
Ohio	4,432,652	2,524,564	1,856,782	1,177,796	1,052,296	489,626	1,230,929	714,010
Oklahoma			21,919	21,361	561,852	324,871	299,635	218,472
Oregon	(a)	(a)						
Pennsylvania	9,840,305	8,790,058	242,128	424,053	159,114	114,650	653,950	574,885
Rhode Island	(a)	(a)						
South Dakota			(a)	(a)			(a)	(a)
Tennessee	155,028	111,141	295,332	237,569	428,233	156,169	197,433	123,590
Texas	84,710	70,548	45,705	32,186	125,178	49,552	429,331	298,088
Utah	278,803	170,332					(a)	(a)
Vermont	(a)	(a)	6,607	3,388	(a)	(a)	4,260	5,088
Virginia	375,469	287,942	444,573	422,090	676,743	353,547	224,649	135,657
Washington	44,045	43,126						
West Virginia	1,726,120	1,409,364	210,766	116,783	186,982	86,872	162,993	115,361
Wisconsin	95,359	80,667	488,848	368,508	(a)	(a)	502,523	492,995
Wyoming								
Undistributed	37,448	35,730	118,033	77,883	182,651	97,811	118,611	104,207
	25,574,146	18,679,213	9,273,282	6,420,257	6,579,905	3,394,495	10,793,455	7,726,346

[a] Included in "Undistributed."

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Limestone sold in the United States in 1917, by uses—Continued.

State.	Sugar factories.		Glass factories.		Paper mills.		Agriculture.		Other (value).	Total value.
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.		
Alabama	(a)	(a)					7,218	$8,428	(a)	$1,278,908
Arizona										140,674
Arkansas							(a)	(a)		84,654
California	124,070	$167,535	(a)	(a)			7,173	17,929	$43,067	364,066
Colorado	117,554	144,125							(a)	532,539
Connecticut							(a)	(a)		(a)
Florida							9,428	19,265	36,586	494,568
Georgia					(a)	(a)	32,537	58,348	8,150	155,172
Idaho	(a)	(a)								37,942
Illinois			(a)	(a)			179,848	126,870	6,057	3,279,737
Indiana	(a)	(a)	(a)	(a)			46,100	39,403	11,104	4,449,809
Iowa	(a)	(a)			(a)	(a)	45,387	24,594	1,936	519,933
Kansas							(a)	(a)	72,774	673,706
Kentucky							25,728	22,362	(a)	1,022,317
Louisiana							(a)	(a)		(a)
Maine					(a)	(a)				(a)
Maryland							(a)	(a)	(a)	307,679
Massachusetts							(a)	(a)		68,392
Michigan	38,287	37,004			29,963	$24,097	62,027	58,148	884,889	3,320,895
Minnesota	(a)	(a)					(a)	(a)	30,728	335,728
Mississippi							(a)	(a)		(a)
Missouri	4,169	2,491	46,285	$48,510			5,992	8,631	47,170	1,679,677
Montana	(a)	(a)								224,986
Nebraska	9,464	12,312							(a)	475,507
Nevada	(a)	(a)								31,625
New Jersey							(a)	(a)	18,336	413,477
New Mexico										(a)
New York					8,169	11,853	82,000	152,394	567,928	3,513,874
North Carolina							67,415	95,288		109,719
Ohio	(a)	(a)	70,508	74,584	(a)	(a)	66,341	93,133	280,629	5,400,578
Oklahoma			(a)	(a)			(a)	(a)	(a)	575,165
Oregon	(a)	(a)					(a)	(a)		4,939
Pennsylvania			85,957	109,862	(a)	(a)	138,323	261,396	234,449	10,569,524
Rhode Island							(a)	(a)		(a)
South Dakota	24,521	36,154								46,130
Tennessee							60,237	97,738		750,639
Texas			(a)	(a)			(a)	(a)	2,872	485,389
Utah	(a)	(a)							(a)	242,707
Vermont					(a)	(a)	15,031	26,894		45,989
Virginia					(a)	(a)	40,580	46,489	(a)	1,263,284
Washington					(a)	(a)	2,764	5,587		59,529
West Virginia			(a)	(a)			4,782	5,430	348	1,788,538
Wisconsin					9,936	6,953	15,090	23,608	11,043	1,172,567
Wyoming	96,288	130,497								130,497
Undistributed	116,259	136,020	90,402	111,523	53,237	52,679	126,252	170,472	18,257	142,450
	530,612	666,138	293,152	344,479	101,305	95,582	1,040,248	1,352,397	[b]2,276,323	[c]46,263,379

[a] Included in "Undistributed."
[b] Value of 4,219,978 short tons.
[c] Value of 63,481,500 short tons.

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Limestone sold in the United States in 1918, by uses.

State.	Rough building.		Dressed building.		Paving, curbing, and flagging.	
	Quantity. (cubic feet).	Value.	Quantity. (cubic feet).	Value.	Quantity. (cubic feet).	Value.
Alabama	(a)	(a)				
Arizona						
Arkansas						
California						
Colorado						
Connecticut						
Florida						
Georgia						
Hawaii						
Idaho						
Illinois	(a)	(a)	(a)	(a)		
Indiana	1,639,443	$618,281	1,063,802	$1,203,377	(a)	(a)
Iowa	b 45,711	b 22,749	(b)	(b)		
Kansas	b 113,497	b 20,279	(b)	(b)		
Kentucky	b 137,234	b 60,520	(b)	(b)	(a)	(a)
Louisiana						
Maine						
Maryland						
Massachusetts						
Michigan	(a)	(a)				
Minnesota	74,078	25,184	39,450	77,948		
Mississippi						
Missouri	169,903	108,114	17,788	35,760	2,248	$1,138
Montana						
Nebraska						
Nevada						
New Jersey						
New Mexico						
New York			(a)	(a)		
North Carolina						
Ohio						
Oklahoma	(a)	(a)				
Oregon						
Pennsylvania	303,343	37,054				
Rhode Island						
South Dakota						
Tennessee	(a)	(a)				
Texas	(a)	(a)				
Utah						
Vermont						
Virginia						
Washington						
West Virginia						
Wisconsin	b 5,841	b 616	(b)	(b)	28,239	30,740
Wyoming						
Undistributed	84,945	55,622	3,000	1,150	7,216	5,958
	2,561,600	943,735	1,136,435	1,322,919	37,698	37,836

a Included in "Undistributed." b Dressed building included in rough building.

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Limestone sold in the United States in 1918, by uses—Continued.

State.	Rubble.		Riprap.		Road making.	
	Quantity. (short tons).	Value.	Quantity. (short tons).	Value.	Quantity. (short tons).	Value.
Alabama			(a)	(a)	(a)	(a)
Arizona						
Arkansas			(a)	(a)	(a)	(a)
California					(a)	(a)
Colorado						
Connecticut						
Florida			(a)	(a)	19,646	$16,356
Georgia					(a)	(a)
Hawaii						
Idaho	(a)	(a)				
Illinois	7,215	$6,503	189,831	$171,504	748,592	489,360
Indiana	2,427	3,963	71,538	42,219	498,901	397,964
Iowa	1,908	1,842	81,314	70,037	50,258	51,729
Kansas	11,885	5,342	36,386	25,246	15,447	15,361
Kentucky	2,310	3,375	32,808	33,280	315,573	355,814
Louisiana						
Maine						
Maryland					60,261	100,579
Massachusetts						
Michigan	(a)	(a)	(a)	(a)	591,781	251,265
Minnesota	6,450	5,280	37,499	24,693	(a)	(a)
Mississippi						
Missouri	18,801	22,993	301,069	249,776	158,759	184,368
Montana	(a)	(a)	(a)	(a)	20,486	18,465
Nebraska	(a)	(a)	64,760	61,125	(a)	(a)
Nevada						
New Jersey			(a)	(a)	12,690	18,532
New Mexico						
New York	19,671	18,123	(a)	(a)	640,566	552,285
North Carolina						
Ohio	8,048	9,505	7,843	6,122	1,628,823	1,350,653
Oklahoma	2,111	2,720	20,888	12,681	22,097	24,483
Oregon						
Pennsylvania	1,743	1,792	(a)	(a)	284,813	381,928
Rhode Island						
South Dakota			(a)	(a)		
Tennessee			(a)	(a)	309,041	243,774
Texas	(a)	(a)	7,170	6,875	107,945	65,425
Utah			(a)	(a)	(a)	(a)
Vermont	(a)	(a)	(a)	(a)	2,625	3,907
Virginia	(a)	(a)			103,193	105,996
Washington						
West Virginia					101,462	135,270
Wisconsin	15,419	22,826	126,543	142,514	267,012	264,502
Wyoming						
Undistributed	8,339	5,105	140,460	123,204	125,366	149,395
	106,327	109,369	1,118,109	969,276	6,085,337	5,177,501

a Included in "Undistributed."

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Limestone sold in the United States in 1918, by uses—Continued.

State.	Railroad ballast.		Concrete.		Flux.	
	Quantity. (short tons).	Value.	Quantity. (short tons).	Value.	Quantity. (long tons).	Value.
Alabama			21,749	$23,548	876,124	$1,060,121
Arizona			(a)	(a)	154,579	146,273
Arkansas	(a)	(a)				
California	(a)	(a)	(a)	(a)	57,973	111,924
Colorado					483,066	422,638
Connecticut			(a)	(a)	(a)	(a)
Florida	(a)	(a)	53,745	54,176		
Georgia			19,461	28,222	(a)	(a)
Hawaii						
Idaho					(a)	(a)
Illinois	717,520	$457,144	1,335,978	964,140	1,015,716	614,958
Indiana	128,316	65,187	145,889	109,304	336,600	209,993
Iowa	(a)	(a)	211,404	192,869	13,172	14,238
Kansas	94,801	87,733	278,379	279,467		
Kentucky	527,454	371,085	78,243	73,330	7,924	7,019
Louisiana			(a)	(a)		
Maine						
Maryland	18,519	21,374	22,781	43,452	119,444	103,969
Massachusetts					(a)	(a)
Michigan	(a)	(a)	389,176	261,877	4,289,289	2,892,179
Minnesota	(a)	(a)	143,041	159,213	(a)	(a)
Mississippi						
Missouri	155,110	110,494	317,844	354,782	89,151	124,988
Montana	(a)	(a)	(a)	(a)	327,800	214,869
Nebraska	(a)	(a)	180,802	218,771	(a)	(a)
Nevada					(a)	(a)
New Jersey			(a)	(a)	481,642	602,546
New Mexico			(a)	(a)		
New York	703,524	710,552	929,566	1,358,690	481,043	425,466
North Carolina			(a)	(a)	(a)	(a)
Ohio	1,129,747	684,192	1,213,899	872,166	3,917,828	3,357,065
Oklahoma	409,145	334,060	201,316	198,611		
Oregon					(a)	(a)
Pennsylvania	86,737	74,361	434,573	550,611	8,689,007	10,473,227
Rhode Island					(a)	(a)
South Dakota			(a)	(a)		
Tennessee	327,962	130,528	308,051	265,291	167,283	139,853
Texas	27,522	15,014	305,247	250,225	89,095	86,663
Utah			(a)	(a)	215,849	168,379
Vermont			12,558	20,608	(a)	(a)
Virginia	521,961	403,377	310,222	326,709	375,824	338,653
Washington					67,418	76,741
West Virginia	137,361	92,686	75,832	96,032	1,392,158	1,595,368
Wisconsin	29,704	19,841	440,287	402,642	140,638	154,151
Wyoming						
Undistributed	494,528	324,064	95,567	89,265	73,406	86,455
	5,509,911	3,901,682	7,525,610	7,194,001	23,862,029	23,427,736

a Included in "Undistributed."

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Limestone sold in the United States in 1918, by uses—Continued.

State.	Sugar factories.		Glass factories.		Paper mills.	
	Quantity. (short tons).	Value.	Quantity. (short tons).	Value.	Quantity. (short tons).	Value.
Alabama						
Arizona						
Arkansas						
California	43,561	$63,023	(a)	(a)		
Colorado	77,751	147,798				
Connecticut						
Florida						
Georgia					(a)	(a)
Hawaii	(a)	(a)				
Idaho	(a)	(a)				
Illinois			(a)	(a)		
Indiana	19,032	24,012	27,303	$37,598		
Iowa	4,173	5,842				
Kansas						
Kentucky						
Louisiana						
Maine					(a)	(a)
Maryland						
Massachusetts						
Michigan	(a)	(a)			27,309	$25,153
Minnesota	(a)	(a)				
Mississippi						
Missouri	(a)	(a)	39,474	59,237	(a)	(a)
Montana	(a)	(a)				
Nebraska	(a)	(a)				
Nevada	(a)	(a)				
New Jersey						
New Mexico	(a)	(a)				
New York			(a)	(a)	15,734	18,920
North Carolina						
Ohio	(a)	(a)	45,544	66,713		
Oklahoma						
Oregon						
Pennsylvania			51,185	93,653	29,404	36,670
Rhode Island						
South Dakota	(a)	(a)				
Tennessee						
Texas			(a)	(a)		
Utah	(a)	(a)				
Vermont					(a)	(a)
Virginia					(a)	(a)
Washington	(a)	(a)			(a)	(a)
West Virginia			(a)	(a)		
Wisconsin					(a)	(a)
Wyoming	89,947	155,792				
Undistributed	201,091	253,122	38,705	75,543	27,800	37,086
	435,555	649,589	202,211	332,744	100,247	117,829

a Included in "Undistributed."

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Limestone sold in the United States in 1918, by uses—Continued.

State.	Agriculture.		Other.		Total value.
	Quantity. (short tons).	Value.	Quantity. (short tons).	Value.	
Alabama	6,241	$8,266	150,200	$230,047	$1,370,667
Arizona					150,350
Arkansas	(a)	(a)			89,640
California	26,077	77,866	33,684	79,694	366,826
Colorado			(a)	(a)	570,649
Connecticut	(a)	(a)	(a)	(a)	(a)
Florida	7,501	14,942	(a)	(a)	256,807
Georgia	36,690	78,492	(a)	(a)	192,515
Hawaii					(a)
Idaho					21,377
Illinois	209,521	185,176	64,026	48,118	2,951,045
Indiana	71,122	64,317	25,640	37,082	2,819,083
Iowa	34,489	19,273			379,029
Kansas			111,317	127,584	561,012
Kentucky	12,959	26,603	1,604	1,469	932,667
Louisiana	(a)	(a)			(a)
Maine					(a)
Maryland	(a)	(a)	(a)	(a)	274,907
Massachusetts	(a)	(a)			92,804
Michigan	160,016	150,604	2,607,546	1,401,900	5,186,867
Minnesota	2,377	2,989	(a)	(a)	310,583
Mississippi	(a)	(a)			(a)
Missouri	5,263	7,211	28,464	91,531	1,359,755
Montana					246,650
Nebraska			(a)	(a)	314,280
Nevada			(a)	(a)	95,821
New Jersey	57,792	51,560			674,397
New Mexico					(a)
New York	58,730	123,774	734,991	699,141	3,918,982
North Carolina	32,365	37,889			58,055
Ohio	61,502	114,726	551,505	496,450	6,960,205
Oklahoma	(a)	(a)	(a)	(a)	574,795
Oregon	(a)	(a)			(a)
Pennsylvania	131,061	325,982	258,562	326,284	12,302,255
Rhode Island					(a)
South Dakota					18,825
Tennessee	63,669	94,399			893,763
Texas	(a)	(a)	(a)	(a)	464,061
Utah			7,544	3,311	341,804
Vermont	12,831	32,542			64,847
Virginia	26,136	38,252	14,812	15,373	1,230,412
Washington	641	2,052	102	430	99,992
West Virginia	2,949	7,974	3,166	1,455	1,958,785
Wisconsin	5,759	8,489	21,053	11,638	1,065,678
Wyoming					155,792
Undistributed	66,227	152,914	39,483	70,990	126,524
	1,091,918	1,626,292	4,653,699	3,642,497	[b] 49,453,006

[b] Value of 53,868,200 short tons. [a] Included in "Undistributed."

The figures in the foregoing tables represent only the quantity and value of limestone sold or used as such by the producers. In addition large quantities of limestone are used in the manufacture of Portland cement and lime and a small quantity is used in the manufature of natural cement. As these products are largely manufactured by the companies quarrying the stone, and as the values of the manufactured products are given in other chapters of Mineral Resources, the quantity and value of the raw material is excluded from the preceding tables of this chapter to avoid duplication. The quantities of limestone quarried for these uses are approximately as follows:

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Limestone used in certain industries in 1915, 1916, 1917, and 1918, in short tons.

	1915	1916	1917	1918
Portland cement (including limestone and some "cement rock")	24,095,355	23,323,220	24,640,230	17,658,700
Natural cement (cement rock)	153,060	158,054	102,260	67,300
Lime	7,179,358	7,685,723	7,194,000	6,400,000
	31,427,773	31,166,997	31,936,490	24,126,000

Thus the total quantity of limestone used for all purposes in 1918 amounted to nearly 78,000,000 short tons, compared with 95,000,000 short tons in 1917.

Closely associated with limestone in commercial usage as well as in chemical consumption and mode of occurrence is calcareous marl. A rough estimate of the quantity of marl used in manufacturing Portland cement in 1918 is 1,100,000 short tons. No data for estimating the cost of production are available. In addition about 98,694 short tons of marl, valued at $261,082, was produced and used in agriculture.

BUILDING STONE.

The limestone sold for use as building stone in 1918 amounted to 3,698,035 cubic feet, valued at $2,266,654, an average price of 61 cents a cubic foot ($7.30 a ton). This was a decrease, as compared with 1917, of 4,783,475 cubic feet (56 per cent) in quantity, $1,848,712 (45 per cent) in value, and 12 cents in average price per cubic foot.

In 1917 limestone as building stone represented 1 per cent of the total quantity of all limestone sold and 9 per cent of the total value, and in 1918 it was less than 0.6 per cent of the total quantity and 4.5 per cent of the total value. The principal districts in which building limestone is produced are the Bloomington-Bedford, in Lawrence and Monroe counties, Ind., and the Carthage, in Jasper County, Mo. A statement of the output and trade conditions of these districts follows.

INDIANA.

PRODUCTION.

The effect of the war on an important branch of the building-stone industry in 1918 was strikingly shown by the greatly reduced sales of Indiana oolitic limestone in the Bedford-Bloomington district, Ind.

The total value of Indiana oolitic limestone sold in 1918 was $1,961,154, a decrease, compared with 1917, of $1,422,956, or 42 per cent. This value was the lowest since 1904, when the stone sold was valued at $1,643,974.

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Indiana oolitic limestone quarried and sold in Lawrence and Monroe counties, Ind., 1913–1918.

Year.	Lawrence County.		Monroe County.		Total.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
1913	[a] 5,737,303	$2,095,461	[a] 3,273,369	$992,286	[a] 9,010,672	$3,087,747
	[b] 91,034	50,092	[b] 67,035	41,508	[b] 158,069	91,600
1914	[a] 5,249,651	1,920,904	[a] 2,679,355	750,311	[a] 7,929,006	2,671,215
	[b] 83,590	30,384	[b] 21,860	17,010	[b] 105,450	47,394
1915	[a] 6,143,282	2,102,814	[a] 2,541,931	830,613	[a] 8,685,213	2,933,427
	[b] 114,547	64,491	[b] 34,032	20,253	[b] 148,579	84,744
1916	[a] 5,940,055	2,519,690	[a] 2,605,479	873,886	[a] 8,545,534	3,393,576
	[b] 187,270	69,546	[b] 24,966	17,403	[b] 212,236	83,949
1917	[a] 5,020,533	2,530,607	[a] 1,754,141	730,500	[a] 6,774,674	3,261,107
	[b] 164,586	88,935	[b] 45,740	34,068	[b] 210,326	123,003
1918	[a] 2,157,672	1,522,476	[a] 544,073	297,691	[a] 2,701,745	1,820,167
	[b] 182,937	129,643	38,141	11,344	[b] 221,078	140,987

[a] Cubic feet. [b] Short tons.

Detailed statistics for 1917 and 1918 are given in the following table:

Limestone quarried and sold in the Bedford-Bloomington district (Lawrence and Monroe counties), Ind., in 1917 and 1918.

County.	Number of plants.	Rough blocks and rough sawed.		Dressed.	
		Quantity (cubic feet).	Value.	Quantity (cubic feet).	Value.
1917.					
Lawrence	14	3,578,058	$1,169,768	1,442,475	$1,360,839
Monroe	19	[a] 1,432,821	461,529	321,320	268,971
	33	[a] 5,010,879	1,631,297	1,763,795	1,629,810
Average price			0.31		0.92
1918.					
Lawrence	11	1,198,587	450,008	959,085	1,072,438
Monroe	13	440,856	168,273	103,217	129,418
	24	1,639,443	618,281	1,062,302	1,201,886
Average price			0.38		1.13
Percentage of increase (+) or decrease (−)		−67.3	−66.1	−39.8	−25.6

County.	Number of plants.	Total.		Other.		Total value.
		Quantity (cubic feet).	Value.	Quantity (short tons)	Value.	
1917.						
Lawrence	14	5,020,533	$2,530,607	164,586	$88,935	$2,619,542
Monroe	19	1,754,141	730,500	45,740	34,068	764,568
	33	6,774,674	3,261,107	210,326	123,003	3,384,110
Average price			0.47		0.58	
1918.						
Lawrence	11	2,157,672	1,522,476	[b] 182,937	[b] 129,643	1,652,119
Monroe	13	544,073	297,691	38,141	11,344	309,035
	24	2,701,745	1,820,167	221,078	140,987	1,961,154
Average price			0.67		0.64	
Percentage of increase (+) or decrease (−)		−60.1	−44.2	+5.1	+14.6	−42.0

[a] Revised.
[b] Includes riprap, rubble, crushed stone, furnace flux, and stone sold to glass works and for agriculture.

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In 1918, as in previous years, almost the entire value (93 per cent) was represented by building stone, whose total quantity was the smallest since figures showing quantity have been collected by the Geological Survey. The large decrease was due to railroad embargoes, scarcity of labor, and curtailment in building for all except war purposes.

In recent years the value of the Indiana oolitic limestone used for building has represented large percentages of the total value of limestone used for building in the United States, 69 per cent in 1913 and 1914; 72 per cent in 1915; 74 per cent in 1916; and 79 per cent in 1917. The quantity in 1916 was 77 per cent of the total quantity of limestone used for building and in 1917 nearly 80 per cent.

In 1916 this stone represented 34 per cent and in 1917 more than 38 per cent of all kinds of building stone sold in the United States.

Twenty-four plants in the Bedford-Bloomington district reported sales of stone in 1918, nine less than in 1917. Three of the plants reported no sales of building stone, their output being confined to crushed limestone, and six plants reported sales amounting to 291,819 cubic feet from stock on hand, their quarries being closed during the year. Two quarrying firms reported their quarries to be idle, their sales consisting of stock from other quarries.

The total quantity of building stone sold in 1918 was 2,701,745 cubic feet, valued at $1,820,167, a decrease, compared with 1917, of 60 per cent in quantity and 44 per cent in value, the average price increasing from 47 to 67 cents a cubic foot. Rough blocks and rough sawed stone amounted to 1,639,443 cubic feet, valued at $618,281, in 1918, a decrease of more than 67 per cent in quantity and 66 per cent in value, for the price per cubic foot rose from 31 to 38 cents. Dressed or manufactured stone amounting to 1,062,302 cubic feet, valued at $1,201,886, decreased nearly 40 per cent in quantity and more than 25 per cent in value, for the price per cubic foot increased from 92 cents to $1.13.

The quarrymen reported decreases of 10 to 35 per cent in their shipments, increases in cost from 25 to 60 per cent, increases in wages of 50 per cent, and increased cost of supplies of 100 per cent. Prices increased from 15 to 40 per cent. One quarryman reported that prices were practically the same as in 1917 until the later part of the season.

The range of prices in the district in 1917 and 1918, as reported by the quarry companies and the milling companies, was as follows:

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Prices of Indiana oolitic limestone per cubic foot in 1917 and 1918.

Quarries.

1917			1918		
High.	Low.	Average.	High.	Low.	Average.
$0.27½	$0.20½	$0.24	$0.30	$0.25	$0.28
.37½	.20½	.24	.40	.30	.35
.45	.12	.31	.50	.30	.30
.65	.40	.55	.53	.12	.30
.70	.15	.43	.60	.15	.25
.88	.20	.61	.65	.13	.38½
1.00	.15	.49½	.75	.25	.40
1.07½	.60	.85	.95	.20	.47
1.50	.80	1.15	1.10	.15	.54
1.60	.98	1.28	1.15	.85	1.00
5.00	.63	1.23	1.50	1.05	1.30
		.98	1.86	1.06	1.46
		.533	2.61	.33	.66
			4.00	.90	1.25
			4.67	.18	1.01½

Mills.

$0.65	$0.30	$0.47	$0.65	$0.40	$0.52½
.65	.40	.52½	.70	.55	.63
.80	.60	.70	.70	.55	.66½
.95	.72½	.84	1.25	.90	1.00
1.20	.90	.95	1.26	1.10	1.18
1.25	.70	1.17	1.30	.85	.95
1.30	.51	.90	1.50	1.10	1.25
1.47	1.07	1.27	1.50	1.10	1.33
1.50	.45	1.06	1.90	.90	1.43
1.50	.80	1.15	1.95	.28	.62
1.75	.45	1.22½	2.00	.40	1.00
2.10	1.11	1.60	3.50	.70	.90
2.50	.90	1.00	4.00	.90	2.21
4.00	.72	1.15			.68
5.00	.85	1.30			.90
		.75			1.00
		.91			
		.95			

The quality of the stone, the size of the blocks, and the amount of dressing regulated the price per cubic foot. The highest prices reported by the quarry companies are those of firms that milled their stone.

The mill owners of this district who buy rough stock made reports of adverse conditions similar to those made by the quarrymen. Business fell off from 33 to 66 per cent. Prices increased 15 to 75 per cent, although one company said the prices were but little higher than they were in 1917, and one company reported that the increase took place in the latter part of the year. The cost of the rough blocks was reported by some companies to be the same as in 1917, but by other companies to have increased from 25 to 40 per cent. According to the reports the cost of operation increased from 15 to 100 per cent, including increased cost of labor ranging from 29 to 130 per cent and increased cost of supplies from 25 to 50 per cent. Building stone was supplied only for buildings where investment was not considered, such as school buildings, hospitals, churches, asylums, and Government buildings. The outlook for 1919 was reported to be good, unless prospective builders refrained from giving contracts on account of the necessarily high prices. The quantity

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and value of the finished stone sold by the mill operators in 1918 was 624,736 cubic feet, valued at $647,851. In 1917 this product was reported to be 1,471,101 cubic feet, valued at $1,788,405, which would represent a decrease in 1918 of more than 57 per cent in quantity and nearly 64 per cent in value. The average price in 1917 was $1.22 per cubic foot and in 1918 it was $1.04. In 1917 the figures of the milling operators included those of the Ingalls Stone Co. and the South Side Stone Co., but in 1918 the Ingalls Stone Co. took over the quarries of the Indiana Limestone Co., and the National Stone Co. absorbed the South Side Stone Co. These changes prevent any good comparison for the two years. The sales reported by the mill operators include 20,989 cubic feet, valued at $18,062, sold for monumental stone, the remainder being building stone. The combined value of the quarry and milling industry in 1917 was $5,172,515, and in 1918 $2,609,005, a decrease of 50 per cent.

SHIPMENTS TO DIFFERENT STATES AND TO CANADA.

In 1917 shipments of stone from the Bedford-Bloomington district were made to 43 States and to Canada. In 1918, in spite of railroad embargoes and curtailment of building work, shipments of building stone were made to 38 States and to Canada. California, Maine, New Hampshire, New Mexico, and Oregon, which received a total of 77,313 cubic feet in 1917, received no shipments of this stone in 1918. Twenty-four other States showed a decrease in shipments which ranged in the principal States from 6 per cent in Iowa, 26 per cent in Nebraska, and 35 per cent in Massachusetts to 50 per cent in Michigan, 51 per cent in Illinois, 56 per cent in Missouri, 58 per cent in Ohio, 65 per cent in Wisconsin, 67 per cent in North Carolina, 78 per cent in Pennsylvania, and 88 per cent in New York. The large shipments reported as made to points in Indiana, the leading State, are due in part to duplication, as stone that was sold by the quarry companies to mill companies in the Bedford-Bloomington district was counted twice. In 1917, after the total quantity shipped by milling companies was deducted, Indiana retained the lead by a large margin; whereas in 1918 the amount of stone which remained in the State (387,979 cubic feet) was slightly less than the amount shipped to Illinois, although Illinois showed a decrease of 51 per cent. Of the States showing increased shipments, the District of Columbia received the largest quantity of stone, 197,354 cubic feet, and increased 15 per cent; Minnesota received 96,278 cubic feet, and increased 11 per cent; Kentucky received 68,320 cubic feet, and increased 293 per cent. The other increases were Arkansas, 150 per cent; Colorado, 8 per cent; Connecticut, 44 per cent; Delaware, 253 per cent; Florida, 200 per cent; Kansas, 20 per cent; Mississippi, 436 per cent; Oklahoma, 26 per cent; and South Carolina, 68 per cent. All the increases except those in Colorado and Wyoming were confined to near-by and Eastern States. Eight States and Canada received shipments of more than 100,000 cubic feet in 1918, whereas 11 States and Canada were credited with more than that quantity in 1917. Notwithstanding the war, only 18 per cent less of the Indiana oolitic limestone was shipped to Canada in 1918 than in 1917.

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Indiana oolitic limestone shipped to different States and Canada in 1917 and 1918, in cubic feet.

	1917			1918		
	By milling companies.	By quarry companies.	Total.	By milling companies.	By quarry companies.	Total.
Canada	2,700	147,538	150,238	7,270	115,210	122,480
Alabama	1,218	22,266	23,484	17,520	2,421	19,941
Arkansas	525	2,784	3,309	1,879	21,731	23,610
California	.....	864	864	.....	.....	.....
Colorado	2,241	9,258	11,499	1,826	10,601	12,427
Connecticut	3,887	27,008	30,895	8,570	36,060	44,630
Delaware	1,158	2,491	3,649	.....	12,874	12,874
District of Columbia	98,989	71,835	170,824	39,672	157,682	197,354
Florida	7,541	1,304	8,845	.....	25,280	25,280
Georgia	7,495	34,716	42,211	538	21,610	25,148
Illinois	96,319	737,599	833,918	57,042	349,011	406,053
Indiana	130,688	2,952,611	3,083,299	85,250	842,197	927,456
Iowa	38,165	151,117	189,282	43,273	123,502	166,775
Kansas	8,033	19,801	27,834	4,984	28,650	33,634
Kentucky	2,886	14,488	17,374	32,906	35,324	68,320
Louisiana	17,280	22,584	39,864	10,088	.....	10,088
Maine	.....	1,617	1,617	.....	.....	.....
Maryland	6,380	8,923	15,503	.....	12,200	12,200
Massachusetts	6,723	87,016	93,739	21,901	38,852	60,753
Michigan	110,118	336,952	447,070	71,281	151,028	222,309
Minnesota	13,275	73,349	86,624	33,871	62,407	96,278
Mississippi	.....	320	320	.....	1,717	1,717
Missouri	63,064	43,801	106,865	14,480	32,591	47,071
Montana	.....	2,119	2,119	.....	1,843	1,843
Nebraska	34,080	111,858	145,938	16,290	91,463	107,753
New Hampshire	802	15,090	15,892	.....	.....	.....
New Jersey	8,120	77,582	85,702	7,237	8,634	15,871
New Mexico	.....	1,492	1,492	.....	.....	.....
New York	133,405	711,570	844,975	5,310	89,616	94,926
North Carolina	62,971	18,312	81,283	3,818	23,053	26,871
North Dakota	5,400	13,642	19,042	2,602	4,177	6,779
Ohio	257,216	236,294	493,510	48,506	154,312	202,818
Oklahoma	8,531	45,863	54,394	4,577	64,045	68,622
Oregon	.....	57,448	57,448	.....	.....	.....
Pennsylvania	217,700	310,121	527,821	33,846	80,219	114,065
Rhode Island	2,700	43,242	45,942	202	24,139	24,341
South Carolina	6,127	17,502	23,629	21,499	18,345	39,844
South Dakota	13,660	12,093	25,753	651	11,335	11,986
Tennessee	1,350	21,045	22,395	1,802	11,166	12,968
Texas	37,784	11,747	49,531	5,164	4,662	9,826
Virginia	11,841	30,413	42,254	9,130	19,428	28,858
West Virginia	31,381	26,487	57,868	6,306	16,892	23,258
Wisconsin	18,212	245,111	263,323	4,986	87,999	92,985
Wyoming	936	41	977	.....	10,972	10,972
	1,471,101	6,779,314	8,250,415	624,736	2,806,248	3,430,984

MINOR PRODUCTS.

In 1918 the quantity of stone which was reported as sold for other than building stone was 221,078 tons, valued at $140,987, and of this quantity 103,348 short tons, valued at $50,560—nearly 50 per cent of the quantity—was sold to iron furnaces and smelters, the open-hearth steel plants receiving 74,978 short tons and the smelters practically all the remainder; 37,426 short tons, valued at $27,546, was sold as ground limestone for agricultural purposes, and the remaining 80,304 tons, valued at $62,881, was sold as riprap, as crushed stone, and as material for glass factories and sugar refineries. A quantity of stone from this district was also used in the manufacture of cement and of lime, but is not included in these figures.

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MISSOURI.

Missouri, which ranks next to Indiana in the production of limestone for building and which showed gains of 17 and 25 per cent, respectively, in 1915 and 1916 and a loss of 48 per cent in 1917, showed a further loss (41 per cent) in 1918. The production of this State is practically confined to the district at Carthage, Jasper County, part of whose output is considered as marble and part as limestone. The total production of this district is shown in the following table:

Limestone and marble sold at Carthage, Jasper County, Mo., 1913–1918.

Year.	Number of producers.	Building stone (rough and dressed).		Monumental stone (rough and dressed).[a]		Curbing.	Flagging.	Rubble.	Other.[b]	Total value.
		Quantity (cubic feet).	Value.	Quantity (cubic feet).	Value.					
1913	7	346,421	$236,524	(a)	(a)	.....	$2,367	$1,500	$18,564	$258,955
1914	7	280,046	206,554	(a)	(a)	.....	2,883	1,951	21,425	232,814
1915	7	367,950	384,959	(a)	(a)	(c)	c 2,614	c 1,220	25,471	414,264
1916	7	426,408	497,357	25,232	$22,054	(c)	c 1,684	2,675	23,029	545,799
1917	7	313,904	302,411	19,819	58,809	.....	1,387	1,030	d 28,806	c 392,443
1918	8	236,885	239,418	25,387	31,798	.....	931	1,811	465,937	c 339,895
Average price, 1918	.....	.....	1.01	.....	1.21	.....	.....	.....	.....	.....
Percentage of increase or decrease	.....	−24.5	−20.8	−17.0	−45.9	.....	−32.9	+76.1	+128.9	−13.3

[a] Prior to 1916 included under "Other."
[b] Includes stone used for monumental work (prior to 1916), crushed stone, stone sold to glass factories, blast furnaces, sugar factories, etc.
[c] Curbing included in flagging; rubble includes riprap.
[d] Represents 33,875 short tons of stone in 1917; 45,677 short tons in 1918.
[e] Represents about 70,600 short tons in 1917; about 70,820 short tons in 1918.

The total quantity sold in this district in 1918 for all purposes was practically the same as in 1917, although the value of the output decreased 13 per cent. The total sales in 1918 were 70,820 short tons, valued at $339,898; in 1917, 70,600 short tons, valued at $392,443.

Although the Carthage district ranks next to the Bedford-Bloomington district, Indiana, its output of building stone was only about 1 per cent of that of the Indiana district in 1918. The quantity of building stone reported is the smallest since statistics showing quantity have been compiled by the Survey, and the value is less than that of any preceding year except 1913 and 1914.

Of the total output of the district in 1918, 263,272 cubic feet (about 21,770 short tons), valued at $271,216, was high-grade building and monumental stone. The output of this class of stone in 1917 was 363,723 cubic feet (about 30,000 short tons), valued at $361,220, a decrease of 27 per cent in quantity and 25 per cent in value for 1918. The stone sold for building in 1918 amounted to 236,885 cubic feet, valued at $239,418, a decrease of 25 per cent in quantity and 21 per cent in value. These decreases in percentages are strikingly less than corresponding decreases in the Bedford-Bloomington district of Indiana, which were 60 per cent in quantity and 44 per cent in value. The average price per cubic foot for building stone was $1.01 in 1918, 5 cents more than in 1917. Of the building stone sold in 1917, 93,964 cubic feet, valued at $142,061—$1.51 per cubic foot—was

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dressed stone, whereas in 1918 the dressed stone reported as sold amounted to only 37,861 cubic feet, valued at $71,760—$1.90 per cubic foot. This decrease of 60 per cent in quantity of dressed stone sold tended to reduce the total value for the district. The rough building stone decreased from 219,940 cubic feet, valued at $160,350—73 cents per cubic foot—to 199,024 cubic feet, valued at $167,658—84 cents per cubic foot.

The stone sold for monumental work, which amounted to 26,387 cubic feet, valued at $31,798, decreased 47 per cent in quantity and 46 per cent in value. The average value was $1.17 in 1917 and $1.21 in 1918. Stone classified by the quarrymen as marble and included in the total amounted to 110,011 cubic feet, valued at $131,023.

Eight companies, one more than in the last six years, reported operations in 1918. They were the Carthage Marble & Building Stone Co., Carthage Marble & White Lime Co., Carthage Quarry Co., Consolidated Stone & Marble Co., the Missouri Quarries Co., the Spring River Stone Co., the Carthage Crushed Limestone Co., and the Independent Gravel Co., all of Carthage. The statistics given do not include the value of the rough stone sold by the quarrymen for crushing; the value given for this stone is its value after crushing. The producers that made statements regarding trade conditions in 1918 reported that business was poor and unsatisfactory, with little demand, and labor scarce and high, costing 25 per cent more than in 1917. Supplies were also reported as 25 per cent higher. The principal trade change reported was the taking over by the Missouri Quarries Co. of the quarry operated during the last few years by John Gill & Co.

The Carthage stone is sold principally in Missouri and the neighboring States of Arkansas, Oklahoma, and Kansas, but it has also been shipped west to California, east to New York, north to Illinois, Wisconsin, Michigan, Minnesota, and Canada, and south to Beaumont, Dallas, and Houston, Tex.

Though the building and monumental stone sold in the Carthage limestone district amounted to 70 per cent of the total value, nearly 65 per cent of the total quantity was sold in the form of broken, crushed, and pulverized limestone and a small quantity in the form of flagging. The total quantity of flagging, rubble, crushed, and pulverized stone sold in 1918 was 49,095 short tons, valued at $68,682; in 1917 it was 35,594 short tons, valued at $31,223, an increase of nearly 38 per cent in quantity and of nearly 120 per cent in value. The average price per ton of this stone in 1918 was $1.40; in 1917, it was 88 cents. Of the quantity stated above, 2,850 short tons, valued at $1.814, represented sales of rubble; 22,902 short tons, valued at $42,819, was stone sold to smelters, sugar factories, glassworks, powder mills, for agricultural use, and, as a substitute for whiting or chalk, or for filler, principally in the manufacture of soap, paint, putty, talc, and rubber; and the remainder was sold for flagging, concrete, and road metal.

OTHER STATES.

Kentucky.—In previous years the limestone quarried near Bowling Green, Warren County, Ky., has ranked in value of output of building limestone next to the Carthage, Mo., district. In 1918, however,

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there were only two quarries in operation and the usual figures of local production are omitted. From reports of the owners of the idle quarries it seems doubtful whether operations will be resumed.

Alabama.—The quarries at Rockwood, Ala., which produce annually a considerable quantity of building stone, were taken over by the Government in July, 1918, and the output of building stone was greatly curtailed. It was the plan of the Government to operate these quarries in connection with the nitrate plants in that vicinity, the stone being of the desired quality and the supply practically unlimited. A considerable amount of new machinery was placed in the quarries and operations were begun on a large scale. The quarries were returned to the owners in March, 1919.

Florida.—The quarry near Miami, Fla., which has been operated extensively for building stone since 1914 was closed in 1918.

Minnesota.—In Minnesota the output of building stone in the two districts, Kasota, Le Sueur County, and Mankato, Blue Earth County, amounted to 85,998 cubic feet, valued at $95,615.

Building stone produced at Mankato and Kasota, Minn., 1916–1918.

Year.	Quantity (cubic feet).	Value.
1916	100,610	$91,323
1917	97,002	112,429
1918	85,998	95,615

These districts also produced 36,892 short tons of stone, valued at $28,745, in 1918 which was sold for rubble, riprap, crushed stone, and agricultural purposes. Building stone was also quarried in Minnesota in 1918 at Mantorville, Dodge County, and small quantities were reported from other localities.

Iowa.—The building stone reported from Iowa was principally from near Postville, Allamakee County; Anamosa and Stone City, Jones County; Keokuk, Lee County; and other scattered localities.

Kansas.—The localities in Kansas reporting building stone in 1918 were at Cottonwood Falls, Clark County; Silverdale, Cowley County; Emporia, Lyons County; Manhattan, Riley County; and other places of less importance.

Pennsylvania.—The building limestone reported from Pennsylvania was not confined to any one district, Howellville, Chester County, and Conshohocken, Montgomery County, furnishing the greater part.

OTHER USES.

PAVING, CURBING, AND FLAGGING.

The limestone sold for paving, curbing, and flagging has become an almost negligible part of the total production. The value of these products in 1918 amounted to less than 0.1 per cent of the total and showed a combined decrease of 44 per cent in value. Indiana, Kentucky, Missouri, and Wisconsin were the only States reporting output of these products.

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RUBBLE.

The output of limestone for rubble, which has decreased continuously for the last nine years, decreased 62 per cent in quantity and 60 per cent in value in 1918. The principal producing States are Wisconsin, Missouri, and New York. Wisconsin and Missouri decreased, but New York showed an increase in value of output. This material is largely the product of the small local quarries and their abandonment on account of substitution of cheaper material has served to reduce the total output materially.

RIPRAP.

Limestone for riprap was one of the few limestone products to show increase in both quantity and value of output in 1918. The production was 1,118,109 short tons, valued at $969,276, a gain of 11 per cent in quantity and 13 per cent in value. Illinois, Indiana, Iowa, Kentucky, Minnesota, and Wisconsin were the principal producing States that increased in quantity and value of production of riprap; Kansas, Missouri, and Nebraska decreased in output. A large part of the riprap work carried on is under the direction of the United States Army Engineers for the improvement of the rivers and harbors. The railroad companies also use this stone for the protection of bridges and tracks.

CRUSHED STONE.

Continued decrease in the output of crushed limestone is shown in the following table:

Crushed limestone sold in the United States in 1916, 1917, and 1918, by uses.

Use.	1916		1917		1918	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Road metal	13,245,634	$7,416,984	9,273,282	$6,420,257	6,085,337	$5,177,501
Railroad ballast	8,088,673	3,650 647	6,579,905	3,394,495	5,509,911	3,901,682
Concrete	10,849,729	6,647,803	10,793,455	7,726,346	7,525,610	7,194,001
	32,184,036	17,715,434	26,646,642	17,541,098	19,120,858	16,273,184
Average price		0.55		0.66		0.85
Percentage of decrease			−17	−1	−28	−7

Of the decrease in total quantity of crushed stone 42 per cent (3,187,945 short tons) was in crushed stone for road metal; 14 per cent (1,069,994 short tons) for railroad ballast; and 44 per cent (3,267,845 short tons), for concrete. In 1917 these percentages were 72 per cent, 27 per cent, and 1 per cent, respectively. The only increase in either quantity or value of crushed stone sold in 1918 was in the value of the stone sold or used for railroad ballast, which increased 15 per cent ($507,187).

Thirty-four States reported crushed limestone in 1918, one less (Nevada) than in 1917. Of the States that produced more than 175,000 tons in 1918, 17 showed decrease in both quantity and value,

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2 (Ohio and West Virginia) showed decrease in quantity and increase in value, and 1 (Tennessee) increased in both quantity and value. Ohio produced 21 per cent of the total crushed limestone in 1918, Illinois 15 per cent, and New York 12 per cent. Each of these States had an output of more than 2,000,000 tons.

FURNACE FLUX.

Limestone used as a flux in pig-iron furnaces, open-hearth steel works, and smelters represented nearly 50 per cent of the total quantity of limestone produced in 1918 and 48 per cent of the value, and for the second time exceeded crushed limestone in both quantity and value of output.

As was indicated by the condition of the iron trade during 1918, the quantity of limestone required by the furnaces during the year was less than in 1917. The output for 1918 amounted to 23,862,029 long tons, valued at $23,427,736, a loss of 1,712,117 long tons (6.7 per cent) in quantity but a gain of $4,748,523 (25.4 per cent) in value. This is the greatest recorded value for furnace flux but the greatest quantity sold was in 1917, during the time of greatest activity in the furnaces and smelters furnishing war material to the allied countries and to this country after its entrance into the war.

The following table shows the production of limestone for flux from 1913 to 1918.

Limestone sold for furnace flux, 1913–1918.

Year.	Quantity (long tons).	Value.	Average price.
1913	22,620,961	$11,103,989	$0.49
1914	15,298,756	7,800,369	.52
1915	18,998,723	9,672,347	.51
1916	23,621,508	13,946,882	.59
1917	25,574,146	18,679,213	.73
1918	23,862,029	23,427,736	.98

Besides the limestone, 16,904 long tons of marble, valued at $15,072, was sold for flux in 1917 and 55,012 long tons, valued at $84,899, in 1918. The production by States is shown for 1917 and 1918 in the tables on pages 1255 and 1259. Production in 1917 was reported from 36 States; in 1918 from 34 States, Arkansas and Kansas not reporting flux in 1918. Sixteen of the States showed decrease in quantity, although seven of these States showed increase in value.

The 18 States showing increase in quantity in 1918 showed also increase in value. Neither the increase nor the decrease was confined to any one section of the country. Pennsylvania continued to produce more than twice as much as any other State, although its output decreased nearly 12 per cent, whereas its value increased 19 per cent. Part of the apparent decrease of 281,694 tons in Alabama's figures was due to the inclusion, in 1917 and earlier years, under "other purposes" (refractories) of a quantity of stone used for the manufacture of "dead-burned" or sintered dolomite and used as a refractory in the open-hearth steel process. Ohio decreased in output of furnace flux 514,824 long tons (12 per cent) but increased in value $832,501

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(33 per cent); West Virginia decreased nearly 20 per cent (333,962 long tons) in quantity but increased 13 per cent in value. Michigan and Illinois were the only two of the larger producing States that increased in production. Michigan's production increased 714,111 long tons (20 per cent) in quantity and $1,258,214 (77 per cent) in value. The average price for this State was 46 cents in 1917 and 67 cents in 1918. The greater part of Michigan's fluxing stone comes from Rogers City, Alpena County, and the large increase in 1918 followed an increase of 542,023 long tons in 1917 and continued a steady increase since 1913. Illinois, whose output of flux decreased in 1917, increased to more than 1,000,000 tons in 1918. New Jersey, Tennessee, Indiana, Arizona, and Washington, which made striking increases in 1917, continued to increase in 1918, whereas Maryland, after a decided increase in 1917, decreased in 1918.

In 1918 an attempt was made for the first time to separate the flux used by pig-iron furnaces, open-hearth steel plants, and smelters, and the result is given in the following table:

Limestone flux used in the United States in 1918, by uses.

Use.	Quantity (long tons).	Value.
Pig iron	15,197,900	$14,738,931
Open-hearth steel	5,134,828	5,997,005
Pig iron and open-hearth steel (not separated)	1,260,723	737,318
Smelters	1,066,282	897,861
Unspecified	1,202,296	1,056,621
	23,862,029	23,427,736

It will be seen that quarrymen were unable to tell the specific use of a little more than 5 per cent of the stone sold as a flux; also that approximately the same quantity was undivided between pig iron and open-hearth steel. It is hoped that a more complete division may be made in 1919. The total output of Arizona and Montana and the greater part of the output of California, Nevada, Texas, Utah, and Washington went to smelters. Pennsylvania furnished about 60 per cent of the stone reported sold to open-hearth steel works and West Virginia about 18 per cent. About one-third of the pig-iron flux was reported from Pennsylvania, one-fourth from Michigan, and about one-fifth from Ohio. The combined pig-iron and open-hearth flux was principally from the Illinois, Indiana, and New York quarries, and the unspecified material was from Illinois, Ohio, and Pennsylvania. It is possible that some of the stone reported as sold to open-hearth works was used as a refractory.

AGRICULTURAL LIMESTONE.

Pulverized limestone for agricultural use which from 1911 has showed a practically steady increase, recovered in 1918 from the slowing up of the industry during 1917 caused by difficulties of transportation and labor. The decrease of less than 1 per cent in 1917, followed by an increase of about 5 per cent in 1918, seems to show the permanence of this comparatively new industry. The output in

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1918 was 1,091,918 short tons, valued at $1,626,292, a record production. The average price per ton was $1.49—19 cents more than in 1917. The burned lime sold for this purpose amounted to 391,047 short tons, a decrease of 20 per cent in 1918, and 34 per cent less than the output in 1911. The relations between sales of pulverized limestone and burned lime for agriculture are shown in the accompany-

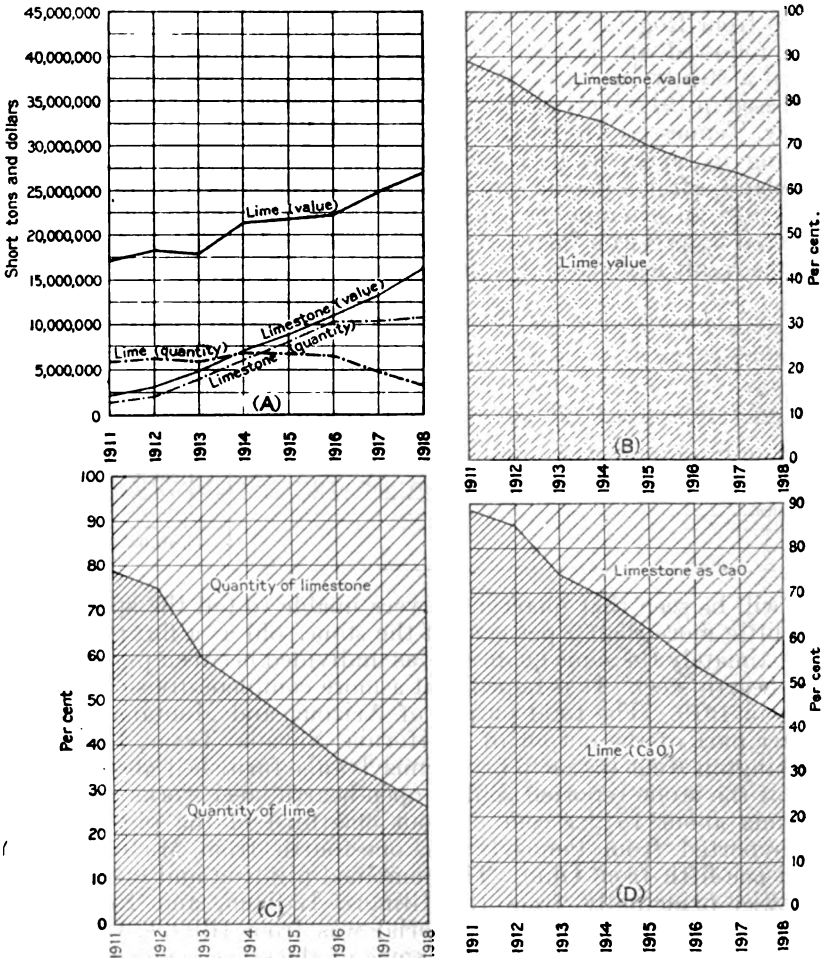

FIGURE 114.—Relations between sales of pulverized limestone and burned lime for agriculture, 1911–1918: A, quantity and value; B, percentages of total value; C, percentages of actual quantity; D, percentages of quantity in terms of calcium oxide (CaO).

ing table and in figure 114. In examining figure 114, D, however, it should be borne in mind that not all of the calcium oxide in limestone may be available for rapid reaction in the soil, as only that portion finer than 60–80 mesh can be considered equivalent to burned or hydrated lime in rapidity of reaction, whereas some of the agricultural limestone sold contains a considerable percentage of coarser grained material.

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Lime and pulverized limestone sold for use in agriculture, 1911–1918.

Year.	Lime.		Limestone.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.
1911	596,664	$1,714,386	174,290	$205,006
1912	604,607	1,852,530	200,000	311,702
1913	590,229	1,798,566	408,627	493,718
1914	684,348	2,139,444	615,197	688,961
1915	673,260	2,163,874	810,399	893,530
1916	613,564	2,224,058	1,043,876	1,109,208
1917	488,297	2,475,731	1,040,248	1,352,397
1918	391,047	2,698,848	1,091,918	1,626,292
Average price per ton		6.90		1.49
Increase or decrease (per cent)	−19.9	+9.0	+4.9	+20.3

The pulverized limestone industry was less affected by the shortage of fuel than the lime industry, and the present high price, the scarcity of fuel, and the increased cost to the producer may prevent the burned lime from resuming its normal for a considerable time. The total quantity of limestone quarried in 1918 for use by farmers was about 1,870,000 tons, whereas in 1917 it was about 2,000,000 tons and in 1916, 2,270,000 tons. In addition to pulverized limestone and burned lime, 78,232 tons of calcareous marl, valued at $203,500, was sold for this use.

In 1918, as in 1917, Illinois was the leading State in quantity of output of ground limestone for agriculture, but Pennsylvania, the third in quantity, stood first in value. Michigan ranked second in quantity. Illinois and Michigan increased in both quantity and value of output, and Pennsylvania decreased in output with increase in value. New York showed decided decrease in both quantity and value.

The agricultural departments of many of the States as well as the United States Department of Agriculture are interested in the testing of both lime and limestone for use on soils, and in many communities the farmers' organizations have crushers and produce the pulverized limestone cheaper than it can be purchased.

SUGAR FACTORIES.

The limestone sold to sugar factories fluctuates in quantity probably more than any other stone product, and the fluctuation does not always conform to the increase or decrease in the production of sugar. The stone sold to sugar factories is burned by them into lime at such times as need arises, and limestone purchased for this purpose may or may not be used in the same year in which it is sold. After an increase of nearly 44 per cent in 1917, the limestone purchased by sugar factories decreased 95,057 short tons (nearly 18 per cent) to 435,555 short tons in 1918. The burned lime sold for this use decreased from 47,546 short tons to 36,494 short tons (23 per cent). This followed an increase of 117 per cent in 1916. The marked increase in 1917 for both lime and limestone was in keeping with the demand for sugar to supply both the needs of the United States and those of foreign countries. The demand still continued in 1918, but

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the stone reported as sold to the factories apparently did not conform thereto.

The following table shows the limestone and lime used by sugar factories, 1915–1918:

Limestone and lime sold to sugar factories, 1915–1918.

Year.	Limestone.		Lime.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.
1915	394,122	$381,038	34,025	$230,368
1916	369,028	369,694	21,923	118,572
1917	530,612	666,138	47,546	381,746
1918	435,555	649,589	36,494	314,78

In 1917 California furnished the largest quantity of limestone for refining sugar, closely followed by Colorado and Wyoming. In 1918, however, Wyoming produced 89,947 short tons, which, although a decrease, exceeded Colorado's production of 77,751 tons. California produced 43,561 tons.

GLASSWORKS.

The limestone sold to glassworks in 1918 amounted to 202,211 tons, valued at $332,744, a decrease of 90,941 tons (31 per cent) in quantity, but of only $11,735 (3 per cent) in value. The average price per ton in 1918 was $1.65; in 1917 it was $1.18.

The burned lime sold to glassworks in 1918 amounted to 34,051 short tons, valued at $265,855—a total value of $598,599 for limestone used in making glass. Pennsylvania, Ohio, Missouri, and West Virginia were the principal producing States.

PAPER MILLS.

The limestone sold to paper manufacturers in 1918 amounted to 100,247 short tons, valued at $117,829, practically the same quantity as in 1917 (101,305 short tons), but an increase of $22,247 (23 per cent) in value. The lime burned and sold for this purpose in 1918 amounted to 325,172 short tons, valued at $2,610,645, a decrease of about 9 per cent in quantity but an increase of 30 per cent in value. Pennsylvania, Michigan, and New York furnished most of the limestone and Pennsylvania, Massachusetts, Maine, New York, and Indiana most of the lime used for this purpose.

MISCELLANEOUS USES.

Limestone sold for miscellaneous purposes reported in the tables on pages 1256 and 1261 includes material produced in only one or two States by individual producers or in quantities too small for segregation. This class of stone represented about 6.4 per cent of the total quantity in 1917 and about 8.6 per cent in 1918. A detailed statement of this limestone by uses, as far as it is possible to publish a statement, is given in the following table:

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Limestone sold for miscellaneous uses in 1917 and 1918.

Use.	1917		1918	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Alkali works	3,124,026	$1,417,898	3,437,066	$2,263,821
Refractories	232,421	171,257	429,863	560,209
Whiting	34,983	75,326	43,011	196,944
Magnesia plants	73,214	89,189	90,989	126,255
Lime burners	59,387	31,736	79,100	65,705
Asphalt filler	39,498	125,648	20,512	52,701
Mineral wool	12,030	8,818	25,640	37,062
Carbonic acid works	(a)	(a)	22,355	36,868
Chicken grit	(a)	(a)	5,432	13,651
Chemical works	(a)	(a)	4,682	10,260
Powder works	(a)	(a)	7,724	8,376
Other uses b	644,419	356,451	426,325	270,625
	4,219,978	2,276,323	4,652,699	3,642,497

a Included in "Other uses."
b Includes stone sold for manufacture of calcium carbide, carbolic acid, nitrates, ammonia, and the purification of copper; for roofing, gravel, filter stone, artificial stone, and other uses not specified.

ALKALI WORKS.

More than 73 per cent of the stone classed as miscellaneous is represented by stone used by alkali works. In 1918 this use amounted to 3,437,066 short tons, valued at $2,263,821, an increase of 10 per cent in quantity and of nearly 60 per cent in value. The greater part of this stone is quarried by the alkali manufacturers, and 64 per cent of it in 1918 was from quarries in Michigan; most of the remainder was quarried in New York, Ohio, and Kansas, but smaller quantities were reported from Pennsylvania and Virginia. Burned lime amounting to 145,031 short tons and valued at $768,570, principally from Virginia, but also from West Virginia, Tennessee, Pennsylvania, and Massachusetts, was also reported as used by alkali works.

REFRACTORIES.

Dolomite or magnesian limestone for refractory use became an important limestone product during the war on account of the cessation of shipments of Austrian magnesite, for which it was substituted. Although it was known that domestic dolomite and the dead-burned or sintered product was used by steel companies long prior to 1914, it was not until that year that the production of a small quantity of sintered dolomite was reported, with the statement that its use was the same as that of magnesite. The quantity previously used was evidently small in comparison to that used since the beginning of the war, and was not reported as a separate item by the producers. Since then it has emerged from the experimental stage until in 1917 about 679,000 short tons, and in 1918 1,129,000 short tons, of dolomite was quarried for this purpose. The chief problem in perfecting this product was the calcining that would prevent slaking of the lime present. The latest and most successful method of doing this is the coating of the sintered product with fused clay or slag. The principal use of sintered dolomite is in granular form for bedding and for plastering walls, replacing granular calcined

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magnesite. Processes for manufacturing it into bricks have been patented, and production of such bricks on a commercial scale may be expected.

Dolomite for refractory use is reported to the Geological Survey under two forms. Part is sold by the quarrying company to the manufacturer and is reported as raw stone; part is both quarried and dead-burned by the manufacturer and is reported as finished product. In order to express the total quantity of raw stone and the equivalent quantity of finished product, the table below gives each item as reported, supplemented by the calculated quantity of the other item.

The great increase in the recorded quantity of dolomite refractories sold in 1918 is in marked contrast to the small decrease in the output of open-hearth steel. The difference is due in part to inclusion of Alabama's output for the first time in 1918. This State's output had formerly been reported as flux for open-hearth steel furnaces, although it was burned before entering the furnace.

Dolomite sold for refractory use was reported as raw stone from Alabama, California, Illinois, Michigan, Ohio, and Pennsylvania; the dead-burned product was reported from Pennsylvania, New York, and Ohio.

Raw and dead-burned dolomite produced for refractory use in 1917 and 1918.

	Quantity (short tons).		Value.	Average price per ton.
	Raw.	Dead burned.		
1917.				
Quarried and burned by producers and reported as dead-burned dolomite		223,300	$2,376,633	$10.66
Equivalent raw stone (approximate)	446,600			
Sold by quarrymen to manufacturers of refractories. Reported as raw stone	232,421		171,257	.74
Equivalent dead-burned product (approximate)		116,210		
	679,021	339,510		
1918.				
Quarried and burned by producers and reported as dead-burned dolomite		318,896	4,097,819	12.85
Equivalent raw stone (approximate)	637,800			
Sold by quarrymen to manufacturers of refractories. Reported as raw stone	490,863		560,209	1.14
Equivalent dead-burned product (approximate)		245,431		
	1,128,663	564,327	4,658,028	

Dolomite for refractory purposes has been used in Europe with indifferent success. A considerable quantity of dolomite was, however, used for refractories in Great Britain during the war and W. W. Jones [32] at a meeting of the refractory materials section of the Ceramic Society, May 22–23, 1919, stated that during the last two and one-half years of the war 127,000 tons of raw dolomite and 410,000 tons of calcined dolomite had been used in Great Britain for munitions purposes.

[32] The Quarry, London, England, June, 1919, p. 164.

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WHITING (CHALK).

Another product whose output has increased through the needs of war is the pulverized limestone used as a substitute for whiting and chalk. In 1916 the rough limestone reported as sold for the manufacture of whiting was 24,722 short tons, valued at $47,435; in 1917, it was 34,983 short tons, valued at $75,326; and in 1918, it was 43,011 short tons, valued at $196,944, an increase in 1918 of 23 per cent in quantity and of 161 per cent in value. This whiting was reported in 1918 from 10 States, Alabama, California, Connecticut, Florida, Illinois, Michigan, Missouri, Nebraska, Nevada, and Utah; in addition 28,815 short tons of pulverized marble ("marble flour"), valued at $86,619, was produced in 1918, a total of 71,826 short tons of whiting, valued at $283,563, sold during the year. In 1917 the total, including marble, was 58,276 tons, valued at $133,957, an increase in 1918 of 23 per cent in quantity and of 112 per cent in value.

The marble for this purpose was from Alabama, Georgia, Massachusetts, New York, and Tennessee. The greater part of this material was reported as sold for paint and putty filler, but it was also sold as a filler for soap, rubber, pottery, and other products which contain whiting.

The average price of the total output was $3.95 a short ton. The individual prices received, however, ranged from $1 to $10 a short ton, evidently because of differences in care of preparation. Some of the specially-treated material sold as high as $20 a ton.

The quantities of whiting reported as used in different industries are not accurately known. According to information received by the Shipping Board, manufacturers of rubber goods consumed about 35 per cent of the total importation of chalk in 1917. Individual companies, however, reported that this consumption was as high as 75 per cent. Accepting 35 per cent as approximately correct, the Shipping Board estimated that about 50 per cent of the total imports was consumed by the paint industries, 10 per cent by the putty trade, and about 5 per cent for other uses, including glazes for ceramic goods, manufacture of leather goods, manufacture of chemicals, molds, and cores in brass foundries, filler for paper, mild abrasives especially for cleaning plate, adulterant in various processes, base for picture molding, and insulators.

When the shortage of ships was becoming increasingly serious during the early part of 1918, the Shipping Board considered curtailment of imports of chalk to half their normal volume, which, because of its bulk, consumed considerable time in loading and unloading. This plan brought protests from many importers and consumers who stated that English chalk or whiting could not be adequately replaced by domestic substitutes. The small curtailment made, however, brought no complaints of shortage nor any vigorous search for superior deposits of domestic chalk then or even later when the steamship companies themselves decided to stop carrying chalk so as to save time. Evidently a sufficient surplus was in the country to bridge over the brief interval of shortage, or domestic whiting made by the extremely fine pulverizing of limestone and

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marble was found adequate for use either alone or mixed with English whiting.

Consumers of imported whiting claimed that it was "amorphous"—a term which, to judge from microscopic examination, implied extremely fine crystalline particles accompanied by colloidal matter—whereas domestic whitings were "crystalline"—that is, of coarser grain and deficient in colloidal matter. Some domestic producers in 1918, however, claimed to be producing material of excellent physical properties, including pure white color, economical absorption of oil, good stretching power (in putty), and ability to take up more marble dust than English whiting. The increased use of domestic whiting tends to confirm these claims, although full confirmation will depend upon the demand in 1919, or since the removal of restrictions on imports. Much of the domestic production in 1918 was consumed in the Central States, but some was shipped to New York and probably other Atlantic ports. One producer shipped from Death Valley to cities in California.

A few producers have been very secret about their raw material and process of manufacture, but others have been very willing to give any information requested. That made as a by-product from the pure-white marble of the Georgia Marble Co., at Tate, Ga., contains between 98 and 99 per cent of calcium carbonate, the remainder being chiefly lime-magnesia silicate. The finest grade produced passed 100 per cent through a screen of 300 meshes to the inch and was used in 1918 chiefly as a rubber filler. In contrast to this, whiting manufactured by the Metro-nite Co., Milwaukee, Wis., contains 44.62 per cent of calcium carbonate, 35.65 per cent of magnesium carbonate, 19.58 per cent of calcium-magnesium silicate, and 0.15 per cent of moisture. Its finest grade will pass 100 per cent through a 225-mesh screen. Domestic whiting manufactured by P. W. Nelson (Inc.), Brooklyn, N. Y., contains 98.50 per cent of calcium carbonate, 0.10 per cent of magnesium carbonate, 0.18 per cent of silica, 0.79 per cent of iron oxides, 0.02 per cent of alumina, and 0.07 per cent of organic matter.

The requirements of whiting for most uses depend on its physical properties, chiefly color, extreme fineness of grain, and the presence of considerable colloidal matter, but no exact specifications for any use except the ceramic industries have been reported to the Survey. According to P. H. Bates,[33] of the Bureau of Standards, Department of Commerce, whiting for the ceramic industries must be very low in iron oxides, preferably not more than 0.05 per cent; its content of calcium carbonate should be about 99 per cent, although it may be as low as 98 per cent if the impurities are only silica and alumina; it must be very fine grained so that practically 100 per cent will pass a 150-mesh sieve. The fineness of whiting must be such that it will not settle instantaneously in water, but that part of it, about 30 per cent, will remain suspended for some time. The chemical requirements will rule out most of the limestones and even some of the white marbles of this country, but some of the white marbles of Vermont, which have proved suitable for the manufacture of optical glass, and

[33] Written communication, May 7, 1918.

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some from Georgia and Alabama, are quite satisfactory in chemical composition.

Mr. Bates also states that it is perfectly possible to prepare whiting from marble if the grinding is carried far enough and conducted with wet material. Perfectly satisfactory material has been produced in this way at the Bureau of Standards. Cost and care to reduce the material to suitable fineness without introducing impurities, particularly iron oxide, are the determining features.

Chemically precipitated calcium carbonate has also been suggested as a substitute for English whiting. Considerable quantities of such calcium carbonate have been made as a by-product from the manufacture of basic magnesium carbonate, but, at least prior to the war, the cost of drying it and keeping it free from impurities has prevented its competition for the whiting market. It doubtless contains considerable colloidal matter; in fact, one manufacturer stated that its absorption of oil, caused probably by the colloidal matter, was too high. A mixture of this chemically precipitated calcium carbonate with finely ground marble, however, should closely approximate English whiting in physical and chemical properties.

Some importers and consumers of whiting in their correspondence with the Shipping Board went so far as to state that there were no deposits of chalk in the United States and Canada. So far as the discovery of extensive high-grade deposits is concerned, this statement is essentially true. Extensive deposits occur, however, in the Cretaceous formations of the West-Central and Southern States and have been quarried by manufacturers of Portland cement, but they are of too low grade for the manufacture of whiting. The chalks of South Dakota, Nebraska, and Kansas contain from 88 to 95 per cent of calcium carbonate, the remainder being principally clay. Several analyses of chalks in southwestern Arkansas show calcium carbonate to range from 90 per cent downward. One analysis showing as much as 98 per cent of calcium carbonate has been reported, but there is no evidence that it represents the average of a workable deposit. The chalks of eastern Texas are essentially continuous with those of Arkansas and attempts to find deposits in them suitable for whiting are said to have failed. The Selma chalk which extends across Alabama and Mississippi is also generally of low grade.

Fresh-water deposits of finely divided calcium carbonate, called fresh-water marl, are also possible sources of suitable material, but they contain as a rule enough organic matter to darken their color. A few samples of unusually white material which may have come from such fresh-water deposits have been received by the Survey, and the suggestion has been made to the senders that it may prove suitable for whiting; but nothing further has been heard from them.

This country's participation in the war was hardly long enough to determine fully its resources of material suitable for whiting. The trend of the industry during 1917 and 1918, however, clearly demonstrated that, should imports be stopped, the country will depend far more on the careful preparation of ground marble and limestone than on the quarrying of chalk or fresh-water marl.

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The imports of chalk are shown in the following table, compiled from figures furnished by the Bureau of Foreign and Domestic Commerce, Department of Commerce:

Chalk, etc., imported for consumption, 1916–1918.

	1916		1917		1918	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Chalk, crude, not precipitated, or otherwise manufactured (duty free).....long tons..	133,188	$112,671	129,711	$126,605	83,933	$113,985
Ground or bolted (duty 0.1 cent a pound).....pounds..	.....	.....	1,195,955	6,241	241,752	5,829
Precipitated, for medicinal purposes (duty 25 per cent).....	.....	27,713	.....	29,980	.....	34,273
Forms of cubes, blocks, sticks, dishes, or otherwise, including tailor's, billiards, etc. (duty 25 per cent).....	.....	4,096	.....	6,583	.....	4,687
French, cut, powdered, washed, or pulverized (duty 15 per cent).....	.....	628	.....	222	.....	266
Manufactured, not elsewhere specified (duty 25 per cent).....	.....	249	.....	340	.....	617
Whiting and Paris white, dry (duty 0.1 cent a pound).....pounds..	2,308,726	9,952	4,054,622	22,485	2,446,180	16,949
Whiting and Paris white, ground in oil or putty (duty 15 per cent).....pounds..	28,334	972	37,230	2,879	14,282	1,904

The principal features of this table are the considerable decreases in the ground or bolted chalk, and of whiting and Paris white. The quantity of ground or bolted chalk decreased about 80 per cent in 1918, and the average price increased from about $10 a ton in 1917 to about $48 a ton in 1918. The whiting and Paris white decreased nearly 40 per cent in quantity and the average price increased from $11 a ton to nearly $14 for the dry material, and that ground in oil or putty decreased 60 per cent in quantity and the average price increased from about $155 a ton to $272 a ton in 1918.

Monthly returns from January to October, inclusive, 1918, showed that imports of crude or unmanufactured chalk were almost exclusively from England, a small quantity being credited to Denmark and a still smaller quantity being entered through Canada. Imports in February, March, April, and May averaged about double those of the other six months. Nearly three-fifths of the total quantity was entered at New York; Philadelphia received less than one-third; and Massachusetts most of the remainder. A small quantity was entered at New Orleans.

Imports of "chalk, ground, precipitated, etc.," also came almost exclusively from England, a small amount being credited to France and trifling sums to Japan, Switzerland, and Canada. Of the imports received during the first six months more than two-thirds of the value was entered at New York; St. Louis, Philadelphia, and Maryland were next in importance; and Chicago, Indiana, San Francisco, Porto Rico, Massachusetts, Hawaii, and Maine-New Hampshire received small amounts.

MAGNESIA PLANTS.

The dolomite quarried in Pennsylvania and Wisconsin and sold principally for the manufacture of basic magnesium carbonate used with asbestos in the manufacture of heat insulating material,

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amounted in 1918 to 90,989 short tons, valued at $126,255, an increase of 24 per cent in quantity and 42 per cent in value.

LIME BURNERS.

Stone reported as sold to manufacturers of lime in 1918 amounted to 79,100 short tons, valued at $65,705, an increase of 33 per cent in quantity and of 107 per cent in value.

This is principally stone quarried in Ohio and shipped to Duluth, Minn., and stone quarried in Michigan and shipped to Niagara Falls, although sales of stone for this purpose were reported in Colorado, Illinois, Missouri, Pennsylvania, Utah, and West Virginia. In these States the stone was not shipped but was burned in the neighborhood of the quarry.

ASPHALT FILLER.

The decrease of 48 per cent in quantity of pulverized limestone sold for asphalt filler in 1918 may be accounted for by the greatly decreased activity of city street work in 1918. The States reporting stone for this purpose in 1918 were California, Illinois, Ohio, and Tennessee in almost equal quantity, and Connecticut, Minnesota, Missouri, New York. Pennsylvania, and Texas in smaller quantity.

MINERAL WOOL.

The stone sold for the manufacture of "mineral wool" in 1918 amounted to 25,640 short tons, valued at $37,082, an increase of 13,610 tons in quantity and of $28,264 in value. Mineral wool is manufactured from low-magnesium argillaceous limestone quarried near Yorktown, Delaware County, and Alexandria, Madison County, Ind., and is used as an insulating material, notably in refrigerators and fireless cookers.

CARBONIC-ACID WORKS.

The 22,355 tons of stone, valued at $36,868, reported as being sold to carbonic-acid plants was quarried in California, Florida, Nevada, and New York. Near Los Angeles, Calif., at one carbonic-acid plant the lime remaining after the carbonic-acid gas is driven off is sold for the manufacture of hydrated lime.

CHICKEN GRIT.

The limestone reported as sold for chicken grit in 1918 amounted to 5,432 short tons, valued at $13,651, and was from California, Illinois, Nevada, Ohio, and West Virginia. Marble, granite, and miscellaneous varieties of stone were also reported as sold for chicken grit, but the sales are not included here.

CHEMICAL WORKS.

California, Maryland, Missouri, and Washington reported stone sold to chemical works without specifying any particular product. The sales amounted to 4,682 short tons, valued at $10,260.

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POWDER WORKS.

Limestone from Illinois, Missouri, and Pennsylvania was sold for use in powder works. The sales reported amounted to 7,724 short tons, valued at $8,376.

OTHER USES.

The largest item included under stone sold for other miscellaneous uses was stone used in calcium carbide works and quarried in Michigan. The remainder of the stone was sold for the manufacture of carbolic acid, nitrates, and ammonia; for the purification of copper; and for roofing gravel, filter stone, and other uses not specified.

WAR USES.

Although crushed limestone was the leading limestone product until 1917, it was displaced by stone for furnace flux during the war. The distribution of limestone with respect to blast-furnace districts was most fortunate and enabled the country to carry on the iron and steel industries at great speed. The demand for flux became so great that several companies that formerly quarried no stone for flux made this their main product.

The quantity of limestone used directly in the chemical industries amounted in both 1917 and 1918 to 5,000,000 short tons and besides this nearly 1,400,000 short tons of burned or hydrated lime was used—a total of about 7,500,000 tons of stone quarried. It has justly been said that limestone and lime are the complement of sulphuric acid as fundamental chemicals for the industrial world. These materials are used in more than 100 industries involving chemical processes, many of them very essential war industries. Little public attention, however, was attracted to so common a commodity as lime, and it may be a matter of some surprise to learn that early in 1918 there was a shortage of high-calcium lime in the Middle Atlantic States after our industries had adjusted themselves to a war basis. To help regulate the supplies of lime the United States Geological Survey cooperated with the National Association of Lime Manufacturers and the War Industries Board by preparing a map showing the location, relative size, kind of product (high calcium or high magnesium) and distribution of output by uses. This served as a basis for economy in transportation of fuel and finished product. It also showed most strikingly the discordance between the principal lime-producing centers and the areal extent of limestone formations. A reduced and simplified copy of this map accompanies the chapter on lime in the Mineral Resources volume for 1918.

Besides forming a basis for the expansion of established industries most essential to the war the limestone resources have met every new demand placed upon them. Some of the cyanamid plants to be established by the Federal Government were located first and the relation of location to certain important raw materials was considered afterwards. The limestone required for one of these plants amounted to 500 tons a day of stone containing 97 per cent of calcium carbonate ($CaCO_3$) within easy transportation distance. The necessary deposits were found—and incidentally a suspicion was confirmed that many published analyses were not representative. Quarries represented by analyses as consisting of nearly pure cal-

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cite rock proved to contain sufficient dolomitic rock to render the quarrying of 500 tons a day of high-calcium stone utterly impossible. The need of accompanying analyses with adequate statements describing the areal extent, thickness, and variations in character of deposits and their relations to quarrying conditions is here apparent, and it is a regrettable fact that most commercial analyses of limestone or lime give no information on these points. Other calls for limestone or lime demand material of a certain degree of purity; as, for example, when the domestic manufacture of optical glass was being considered a call was made for limestone containing less than 0.05 per cent of Fe_2O_3, and very few analyses of quarried limestones could be found in which alumina and iron oxide were separately determined. The extraordinary growth of the use of limestone in the chemical industries, as well as the present trend in the purely geological study of sedimentary rocks, calls for more complete analyses than have ordinarily been made.

Domestic limestone and lime have also successfully replaced materials formerly imported. Some of these, like "Vienna lime," ("Wienerkalk") were imported in small quantities for special uses and have no appreciable effect on the quantity of lime consumed, although the demand for these small quantities may be urgent. One product, however, has been developed on a large scale and its manufacture shows promise of surviving the war period as a permanent industry; this is dead-burned or sintered dolomite, which has largely replaced foreign magnesite and has successfully competed with domestic magnesite as a refractory largely because of its geographic position. Its production is discussed on page 1277 under the head of refractories.

LITHOGRAPHIC STONE.

No production of lithographic stone was reported to the Survey in 1918, and no stone was imported for lithographic work during the year. The quarry at Brandenburg, Ky., which so far has furnished all the commercial domestic lithographic stone used in the United States, was operated irregularly for crushed stone, for hones, and for other products of limestone, the owner having joined the army in the spring of 1918 and the sales office being closed.

SANDSTONE.

GENERAL STATISTICS.

The production of sandstone in the United States has decreased each year since 1903, except in 1909, 1913, and 1914. The sales in 1918 amounted to 2,858,100 short tons, valued at $4,529,298, a decrease of 26 per cent in quantity and about 18 per cent in value from the output in 1917. In 1918 as in 1917 sandstone represented 4 per cent of the total quantity of all stone sold, whereas the value in 1917 was 6.7 per cent and in 1918 it was 5.5 per cent of the total value.

PRODUCTION BY STATES.

The four leading States in 1918, which contributed more than 70 per cent of the total value of sandstone, were Pennsylvania ($1,543,544), Ohio ($957,535), Wisconsin ($353,030), and New York ($325,-

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351). Wisconsin was the only one of these States to show increased sales—the result of a large gain in both quantity and value of ganister. All sandstone products in Pennsylvania decreased in both quantity and value except ganister, which increased in value but decreased in quantity. New York showed large decreases in all classes of sandstone and was exceeded in total value by Wisconsin. In 1913 New York ranked first among the sandstone-producing States; in 1914, second; in 1915, third; and in 1918, fourth. This decrease was due at first to the large decrease in the production of bluestone and recently to an increase in the production of ganister in other States. New York's output is mostly for construction work—building, paving, flagging, and curbing—which has necessarily been greatly curtailed in the last two years. Ohio continued in second place among the sandstone States, but with decreased value, for practically all products except ganister and flagging. The only States besides Wisconsin to show increase in value of production were Arkansas (7 per cent), for riprap; North Carolina (27 per cent), continuing the increase begun in 1917 by stone quarried for the construction of a dam; Virginia (39 per cent), for crushed stone; and West Virginia (25 per cent), for ganister. The number of quarries reporting operation in 1918 was 270, compared with 356 in 1917 and 436 in 1916.

Value of sandstone (including quartzite and bluestone) sold in the United States, 1914–1918.

State.	1914	1915	1916	1917	1918
Alabama	$161,773	$30,432	$20,995	$17,098	$14,484
Arizona	23,760	9,625	(a)	(a)	(a)
Arkansas	79,358	54,747	95,398	66,183	70,593
California	277,657	336,629	422,225	232,379	188,163
Colorado	97,029	52,487	53,902	90,646	81,226
Connecticut	(a)	(a)	(a)	(a)	(a)
Idaho	22,837	10,302	47,061	56,702	42,040
Illinois	72,738	43,307	40,343	42,304	(a)
Indiana	(a)	(a)			
Iowa	1,319	(a)	(a)	(a)	
Kansas	2,274	(a)	3,495	(a)	(a)
Kentucky	60,926	70,164	114,136	96,117	37,827
Maryland	8,128	11,038	6,008	(a)	(a)
Massachusetts	428,926	353,662	318,962	216,500	200,577
Michigan	(a)	(a)	21,449	(a)	(a)
Minnesota	210,099	173,995	186,179	81,717	(a)
Missouri	3,588	10,104	14,991	6,862	(a)
Montana	(a)	6,346	(a)	(a)	(a)
Nebraska	(a)	(a)	(a)	(a)	(a)
New Jersey	53,394	68,964	46,035	6,758	17,652
New Mexico	412,845	296,809	18,330	(a)	(a)
New York	b 1,475,231	b 1,000,523	b 714,558	b 760,582	b 325,351
North Carolina	(a)	27,544	(a)	228,048	288,681
Ohio	1,523,796	1,411,333	1,274,181	1,086,027	957,535
Oklahoma	1,934	2,525	24,229	5,006	(a)
Oregon	(a)	(a)	(a)	(a)	(a)
Pennsylvania	b 1,140,182	1,273,994	b 1,318,239	b 1,794,919	b 1,543,544
South Dakota	126,413	119,225	163,735	116,785	58,736
Tennessee	(a)	(a)	(a)	(a)	(a)
Texas	197,900	73,128	85,940	(a)	(a)
Utah	67,578	27,267	27,207	25,021	(a)
Virginia	150,469	178,775	66,217	34,058	47,309
Washington	450,436	(a)	(a)	(a)	45,368
West Virginia	142,459	124,929	48,416	52,543	65,740
Wisconsin	167,595	180,198	188,791	291,241	353,030
Wyoming	11,831	10,840	(a)	(a)	(a)
Undistributed	129,433	141,908	282,741	204,835	196,452
	7,531,808	6,065,800	5,603,778	5,512,421	4,529,298

a Included in "Undistributed." b Includes bluestone.

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PRODUCTION BY USES.

The quantity and value of sandstone sold are summarized by uses in the first of the accompanying tables and are given in more detail in the second. In the first table quantities are expressed in the units ordinarily used by the trade and also approximately in equivalent short tons.

Sandstone sold in the United States in 1917 and 1918, by uses.

Use.	1917		1918	
	Quantity.	Value.	Quantity.	Value.
Building stone.....cubic feet..	[a] 2,579,750	$1,043,226	973,990	$536,474
Approximate equivalent in short tons.....	(211,540)		(75,650)	
Paving blocks.....number..	[a] 7,033,500	352,808	2,188,419	148,091
Approximate equivalent in short tons.....	(70,940)		(21,900)	
Curbing.....cubic feet..	[b] 1,361,210	651,564	531,952	298,971
Approximate equivalent in short tons.....	(b 112,300)		(43,800)	
Flagging.....cubic feet..	[b] 1,023,500	348,000	798,934	373,729
Approximate equivalent in short tons.....	(b 84,500)		(65,900)	
Crushed stone.....short tons..	1,520,981	1,400,705	882,831	1,060,106
Riprap.....do....	342,485	263,464	356,784	305,308
Rubble.....do....	146,584	65,667	105,022	107,958
Ganister.....do....	1,301,177	1,350,500	1,297,874	1,688,334
Other.....do....	[a] 90,000	36,487	8,355	20,327
Total (quantities approximate, in short tons).	[b] 3,880,500	5,512,421	2,858,100	4,529,298

[a] Partly estimated. [b] Partly estimated and revised.

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Value of sandstone (including quartzite and bluestone) sold in the United States in 1917.

State.	Rough building.	Dressed building.	Ganister.	Paving.	Curbing.	Flagging.	Rubble.	Riprap.	Crushed stone.			Other.	Total.
									Road metal.	Railroad ballast.	Concrete.		
Alabama	(a)	(a)	(a)				(a)	(a)					$17,098
Arizona	(a)							(a)					(a)
Arkansas	(a)							(a)	(a)	$4,266	(a)	(a)	66,183
California	$8,000						(a)	(a)	$61,575		$144,377	(a)	232,379
Colorado	14,534	$25,967	$32,137	(a)	$2,216	$654	$3,071	(a)			(a)		90,646
Connecticut	(a)	(a)					(a)	(a)				(a)	(a)
Idaho	(a)	(a)					(a)					(a)	56,702
Illinois	(a)		(a)						(a)				42,304
Iowa							(a)					(a)	(a)
Kansas	(a)					(a)	(a)						(a)
Kentucky	(a)	51,615					3,541	$19,985	(a)	(a)	(a)		96,117
Maryland	(a)		(a)						(a)		(a)		(a)
Massachusetts		(a)							(a)		154,500		216,500
Michigan	(a)	(a)					(a)	(a)					(a)
Minnesota	(a)	(a)		(a)	(a)	(a)	(a)		(a)		15,150		81,717
Missouri	(a)	(a)					(a)	(a)				(a)	6,862
Montana	(a)	(a)											(a)
Nebraska	(a)						(a)						(a)
New Jersey	(a)							(a)					6,758
New Mexico							(a)						(a)
New York	38,209	102,346	(a)	$171,566	275,254	46,783	(a)	8,491	(a)	21,413	47,007	$5,445	760,582
North Carolina	(a)	(a)					(a)			(a)	(a)		228,048
Ohio	92,691	342,462	(a)		305,581	274,150	5,719	49,302	(a)	(a)	(a)	4,356	1,086,027
Oklahoma	311	(a)					(a)				(a)		5,096
Oregon								(a)					(a)
Pennsylvania	57,080	100,507	1,114,696	73,087	59,321	26,187	24,151	16,498	85,522	94,928	121,897	21,045	1,794,919
South Dakota	(a)	(a)	(a)	14,375			(a)	1,604	(a)		85,433	(a)	116,785
Tennessee			(a)										(a)
Texas								(a)		(a)	(a)	(a)	(a)
Utah	(a)			(a)	(a)								25,021
Virginia									(a)	(a)			34,058
Washington		(a)					(a)	(a)					(a)
West Virginia	8,761	(a)	(a)		(a)		4,756	(a)	15,910		14,709		52,543
Wisconsin	28,260	(a)	167,385	44,711			2,147	2,950	25,402		(a)	6.8	291,241
Wyoming							(a)	(a)			(a)		(a)
Undistributed	46,792	125,691	36,282	49,069	9,192	226	22,282	164,634	210,286	27,472	270,858	5,033	204,835
	294,638	748,588	1,350,500	352,808	651,564	348,000	b65,667	c263,464	398,695	148,079	853,931	30,487	5,512,421

a Included in "Undistributed." b Value of 146,584 short tons of stone. c Value of 342,485 short tons of stone.

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Sandstone sold in the United States in 1918.

State.	Rough building (rough blocks or rough sawed).		Dressed building.		Ganister.		Paving.	
	Quantity (cubic feet).	Value.	Quantity (cubic feet).	Value.	Quantity (short tons).	Value.	Quantity (number of blocks).	Value.
Alabama	(a)	(a)			(a)	(a)		
Arizona	(a)	(a)						
Arkansas								
California	(a)	(a)						
Colorado	b 33,677	b $7,558	(b)	(b)	43,051	$56,163		
Connecticut	(a)	(a)	(a)	(a)				
Idaho	b 50,732	b 40,955	(b)	(b)				
Illinois					(a)	(a)		
Kansas								
Kentucky	(c)	(c)	c 51,443	c $20,918				
Maryland					(a)	(a)		
Massachusetts								
Michigan	(a)	(a)						
Minnesota					(a)	(a)	(a)	(a)
Missouri	(a)	(a)						
Montana	(a)	(a)			(a)	(a)		
Nebraska								
New Jersey			(a)	(a)				
New Mexico								
New York	40,206	15,894	29,647	45,048	(a)	(a)	1,241,263	$84,408
North Carolina	(a)	(a)			(a)	(a)		
Ohio	b 4 86,983	b 292,480	(b)	(b)	48,019	102,447		
Oklahoma	(a)	(a)						
Oregon								
Pennsylvania	124,671	18,963	13,067	29,900	858,374	1,142,202	418,759	26,393
South Dakota			(a)	(a)	(a)	(a)		
Tennessee	(a)	(a)						
Texas								
Utah	(a)	(a)						
Virginia			(a)	(a)				
Washington	(a)	(a)					(a)	(a)
West Virginia					(a)	(a)		
Wisconsin	b 38,234	b 11,256	(b)	(b)	276,424	303,760	334,846	24,146
Wyoming								
Undistributed	101,720	43,471	3,610	10,031	72,006	83,762	193,551	13,144
	800,062	343,726	173,928	192,748	1,297,874	1,688,334	2,188,419	148,091

a Included in "Undistributed."
b Dressed building included under rough building.
c Rough building included under dressed building.

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Sandstone sold in the United States in 1918—Continued.

State.	Curbing.		Flagging.		Rubble.		Riprap.	
	Quantity (cubic feet).	Value.	Quantity (cubic feet).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Alabama							(a)	(a)
Arizona					(a)	(a)	(a)	(a)
Arkansas					(a)	(a)	40,480	$59,850
California			(a)	(a)	(a)	(a)	(a)	(a)
Colorado	(a)	(a)			3,047	$3,154	(a)	(a)
Connecticut								
Idaho					(a)	(a)		
Illinois								
Kansas			(a)	(a)			(a)	(a)
Kentucky			(a)	(a)	(a)	(a)	21,190	12,485
Maryland								
Massachusetts								
Michigan					(a)	(a)	(a)	(a)
Minnesota					(a)	(a)	(a)	(a)
Missouri								
Montana					(a)	(a)		
Nebraska					(a)	(a)	(a)	(a)
New Jersey					(a)	(a)	(a)	(a)
New Mexico					(a)	(a)		
New York	207,981	$131,940	43,512	$25,124	(a)	(a)	9,915	7,256
North Carolina					(a)	(a)	(a)	(a)
Ohio	305,571	155,994	717,312	327,767	6,837	6,458	66,508	46,472
Oklahoma								
Oregon							(a)	(a)
Pennsylvania	17,000	10,353	29,740	17,097	17,652	29,499	5,194	12,661
South Dakota					(a)	(a)	13,580	11,927
Tennessee					(a)	(a)		
Texas							(a)	(a)
Utah								
Virginia								
Washington					(a)	(a)	(a)	(a)
West Virginia	(a)	(a)			2,840	5,143	(a)	(a)
Wisconsin					1,370	921	21,211	9,666
Wyoming							(a)	(a)
Undistributed	1,400	684	8,370	3,741	73,276	62,783	178,706	144,991
	531,952	298,971	798,934	373,729	105,022	107,958	356,784	305,308

a Included in "Undistributed."

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Sandstone sold in the United States in 1918—Continued.

State.	Road making.		Railroad ballast.		Concrete.		Other.		Total value.
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	
Alabama							(a)	(a)	$14,484
Arizona									(a)
Arkansas	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	70,593
California	(a)	(a)	(a)	(a)	129,628	$104,022			183,163
Colorado					(a)	(a)	(a)	(a)	81,226
Connecticut									(a)
Idaho							(a)	(a)	42,040
Illinois	(a)	(a)							(a)
Kansas							(a)	(a)	(a)
Kentucky					(a)	(a)			37,827
Maryland									(a)
Massachusetts	(a)	(a)			61,545	144,577			200,577
Michigan	(a)	(a)					(a)	(a)	(a)
Minnesota					(a)	(a)			(a)
Missouri									(a)
Montana							(a)	(a)	(a)
Nebraska									(a)
New Jersey									17,652
New Mexico									(a)
New York	(a)	(a)	4,295	$3,222	(a)	(a)	(a)	(a)	325,351
North Carolina			(a)	(a)	(a)	(a)			288,681
Ohio	12,550	$18,050	(a)	(a)	(a)	(a)	5,552	$12,174	957,535
Oklahoma					(a)	(a)	(a)	(a)	(a)
Oregon									(a)
Pennsylvania	62,183	74,522	81,797	87,709	77,753	94,217	(a)	(a)	1,543,544
South Dakota	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	58,726
Tennessee									(a)
Texas					(a)	(a)			(a)
Utah									(a)
Virginia	(a)	(a)	(a)	(a)	(a)	(a)			47,309
Washington							(a)	(a)	45,368
West Virginia	12,500	19,400			6,200	6,300	(a)	(a)	65,740
Wisconsin	4,278	1,573			(a)	(a)	781	1,563	353,030
Wyoming					(a)	(a)			(a)
Undistributed	169,552	161,135	85,450	52,053	175,100	288,326	2,022	6,590	196,452
	261,063	269,680	171,542	142,984	450,226	637,442	8,355	20,327	4,529,298

[a] Included in "Undistributed."

BUILDING STONE.

Sandstone for building purposes decreased from 2,579,750 cubic feet, valued at $1,043,226, in 1917 to 973,990 cubic feet, valued at $536,474, in 1918, a decrease of 62 per cent in quantity and of 49 per cent in value, and following a decrease of 32 per cent in quantity and 20 per cent in value in 1917. The average price was 40 cents a cubic foot ($4.93 a ton) in 1917 and 55 cents ($7.09 a ton) in 1918.

The increase in value of stone sold rough for building and the large decrease in the value of dressed stone sold is partly accounted for by a difference in classification in 1917 and in 1918. In 1917 all sawed stone was included under dressed stone, while in 1918 the rough sawed stone was included with rough blocks.

The three principal producing States were Ohio, New York, and Pennsylvania.

The chief localities in Ohio that furnished building stone were the well-known districts near Amherst and North Amherst in Lorain County; Berea and South Euclid in Cuyahoga County; Wakeman in Huron County; McDermott in Scioto County; the more recently developed districts at Glenmont in Holmes County,; and Sherrodsville

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in Carroll County. In New York, the bluestone quarries near Norwich in Chenango County and Portageville in Wyoming County furnished most of the building material. In Pennsylvania, besides the quarrying of building stone at Waltonville in Dauphin County, there were no special operations for building sandstone in 1918, although stone in stock was sold from a number of small quarries. The sandstone quarries in Stone City, Pueblo County, Colo., which furnished a considerable quantity of building stone in 1917, were less active in 1918. There was increased production of building stone in 1918 at the Table Rock quarries near Boise in Ada County, Idaho, which furnished stone for some new dormitories of Yale University, New Haven, Conn. Output decreased at the "freestone" quarries near Farmers and Freestone in Rowan County, Ky. The quarry at Langfords in Rockcastle County was idle during 1918, as were the quarries at Kingwood in Preston County, W. Va.; and at Port Wing in Bayfield County, Wis. The quarries at Colfax and Dunnville in Dunn County, Wis., decreased in output of building stone in 1918. The selling of the stone from the Dunnville quarries, which has long been used throughout Wisconsin, in St. Paul and other places in Minnesota, in Iowa, North Dakota, and South Dakota, as a building stone, has recently been placed in the hands of a New York firm, and stone from these quarries has been shipped to New York for interior decoration of the Richmond County courthouse at Richmond, N. Y. There was less building stone quarried at Jacobsville, Houghton County, Mich., in 1918, and it was reported that this quarry, which has furnished building stone for many years, has been abandoned. There was increased production at the building-stone quarries near Wilkeson in Pierce County, Wash., in 1918. The remainder of the building sandstone sold was from less known localities and mostly for local use.

PAVING BLOCKS.

The sandstone sold for paving blocks in 1918 amounted to 21,900 tons (2,188,419 blocks), valued at $148,091. This was a decrease of 49,049 short tons (4,905,081 blocks) in quantity and of $204,717 in value. The average price was $6.76 a ton ($67.67 a thousand blocks) in 1918 and $4.97 a ton ($49.74 a thousand blocks) in 1917. Sandstone paving blocks were reported from five States in 1918 compared with seven States in 1917 and 13 States in 1916. New York, Pennsylvania, and Wisconsin were the principal producers, with small outputs from Minnesota and Washington. The relation of producing centers to markets is illustrated on Plate XIV. In Minnesota the paving blocks are produced at Sandstone in Pine County, and in 1918 they were all shipped to St. Paul. The sandstone paving blocks sold in New York in 1918 decreased in value $87,158 (51 per cent) compared with 1917. The producing localities were near Albion and Hurlburton, Orleans County (1,072,513 blocks valued at $74,960), and at Hammond, St. Lawrence County (169,750 blocks valued at $9,448). The blocks made in these two districts were shipped to Buffalo, N. Y. (432,375 blocks), Cleveland, Ohio (390,478 blocks), Rochester, N. Y., and Akron, Ohio (each about 105,600 blocks), Oswego, N. Y. (37,860 blocks), and the remainder to Tonawanda, Syracuse, and Amsterdam, N. Y.

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Sandstone paving blocks produced in Pennsylvania in 1918 decreased in value 64 per cent, compared with 1917. The blocks were produced at Whitehaven in Luzerne County and were shipped to Scranton, and at Branch, Long Bridge, Hillside, and Ligonier in Westmoreland County and were shipped to Pittsburgh. The total quantity was 418,759 blocks. The sandstone paving blocks reported from Washington were quarried at Wilkeson in Pierce County, and no statement was made of the locality of consumption, but it was probably Seattle. The sandstone paving blocks produced in Wisconsin were from Ableman in Sauk County, Stevens Point in Portage County, and Grand Rapids in Wood County. The total amounted to 334,846 blocks, valued at $24,146, a decrease of 46 per cent in value for 1918. These blocks were all shipped to Milwaukee.

CURBING AND FLAGGING.

The sandstone sold for curbing and flagstone, which in 1918 represented about 4 per cent of the total quantity and 15 per cent of the total value of all sandstone sold, has shown a continuous decrease for several years, caused by the increasing use of concrete for these purposes. The value of the curbing sold in 1918 was $298,971—$352,593 less than in 1917. The value of flagging was $373,729, an increase of 7 per cent. This increase was occasioned by increase in average price, as the quantity sold decreased about 22 per cent.

The calculation of figures of quantity for these two products is found to be rather unsatisfactory, inasmuch as many of the producers report the quantity of curbing sold in linear feet and the quantity of flagging in square feet. As there is no standard for the other dimensions necessary for conversion to a common unit, the conversion to cubic feet has been based on an average thickness for both products. Curbing varies from 2 inches to 8 inches in thickness and the length 18 inches to 2 or 3 feet or more. Flagging varies from one-half inch to 5 inches in thickness, the average being about 2½ inches. Ohio, which is the largest producing State for both curbing and flagstone, showed decrease in both quantity and value of curbing, but decreased quantity with increased value for flagging.

New York and Pennsylvania, the only other States which produce these products to any extent, showed large decreases in both quantity and value of output.

RUBBLE AND RIPRAP.

The sandstone sold for rubble, the cheapest form of stone building material, did not show as large a decrease in 1918 as might have been expected from the conditions of labor and the building trades. The output was 105,022 tons, valued at $107,958—a decrease of 28 per cent in quantity, but an increase of 64 per cent in value. The average price in 1917 was 45 cents, in 1918 it was $1.03. The sandstone sold for riprap which is subject to irregular demand for construction and repair of river and harbor work increased in both quantity (4 per cent) and value (16 per cent). The output in 1918 was 356,784 short tons, valued at $305,308.

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As the production of riprap and rubble is confined usually to only one or two producers in most of the States, very few State figures can be published.

GANISTER.

Sandstone (quartzite) in its use as ganister or refractory material for making silica brick, ferrosilicon, and furnace or converter linings, took its place during the war as an important stone product. This was shown by its increase of 50 per cent in quantity in 1916 and of 51 per cent in 1917.

This great increase, when compared with the smaller increases of materials on which its use formerly depended, suggests a broadening of its usefulness supplementing or displacing certain other refractories. One cause of its increased use was the growth of the by-product coke industry in which ganister bricks have proved very satisfactory. The requisite qualities for ganister are a content of 98 per cent of silica (SiO_2) and not more than 1½ per cent of alumina and the ability to be finely crushed into fine angular fragments. Loose sand and sandstones that are reduced to the original rounded sand grains on crushing yield a weaker brick, less able to withstand either handling before burning or the changes in volume during burning, when the original quartz is transformed to a microcrystalline mass of tridymite and cristobalite. The great increase in demand for ganister has caused the opening of new quarries in the producing districts, but very few inquiries have been made by prospective producers regarding the location of undeveloped deposits.

Detailed information on the manufacture, properties, and uses of silica brick is contained in the following articles:

McDowell, J. S., A study of the silica refractories: Am. Inst. Min. Eng. Trans., vol. 57, pp. 3–61, 1918.

——— Composition of refractory silica brick: Eng. and Min. Jour., May 25, 1918, pp. 954–956.

Le Chatelier, H., and Gogitch, B., The manufacture of silica brick: Am. Inst. Min. Eng. Bull., September, 1918, pp. 1435–1462.

Gray, Walter, Silica brick and some new uses of them: Met. and Chem. Eng., Feb. 15, 1917, pp. 209–216.

Ross, D. W., Silica refractories: U. S. Bur. Standards Tech. Paper 116, 1919.

The ganister used in 1918 amounted to 1,297,874 short tons, valued at $1,688,334. The quantity produced is nearly 0.3 per cent less than that produced in 1917. This slight decrease shows a check on the rapid development of the industry. In 1918 the value increased 25 per cent; in 1917 it increased 155 per cent; and in 1916, 58 per cent. In 1918 the average price per ton was $1.30; in 1917 it was $1.04; and in 1916 it was 62 cents. The advance in price in 1918, as in 1917, was due mainly to increase in the cost of production, and the decrease in output was due to scarcity of labor and the cessation of abnormal demand after the armistice was signed, in November, 1918.

Ganister sold in the United States in 1915–1918.

Year.	Quantity (short tons).	Value.	Year.	Quantity (short tons).	Value.
1915	573,304	$336,267	1917	1,301,177	$1,380,500
1916	859,956	529,805	1918	1,297,874	1,688,334

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In 1918, for the first time, the statistics or ganister were assembled to show the production of the stone according to uses, and the result is given in the following table:

Ganister sold in the United States in 1918, by uses.

State.	Silica brick.		Furnace and converter linings.		Ferrosilicon.		Total.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Pennsylvania	688,104	$888,473	110,961	$159,801	59,289	$93,928	858,374	$1,142,202
Wisconsin	254,602	282,224	21,822	21,536	.....	.....	276,424	303,760
Ohio	.....	.....	48,019	102,447	.....	.....	48,019	102,447
Colorado	25,627	43,106	[a] 17,424	[a] 13,057	(a)	(a)	43,051	56,163
West Virginia, North Carolina, Maryland, and Tennessee.	[b] 20,944	[b] 29,545	16,705	10,066	(b)	(b)	37,649	39,611
Undistributed [d]	22,296	32,705	(c)	(c)	[c] 12,061	[c] 11,446	34,357	44,151
	1,003,060	1,259,384	215,164	312,230	79,650	116,720	1,297,874	1,688,334
Average price per ton	.....	1.26	.....	1.44	.....	1.47	.....	1.30

[a] Ferrosilicon included under furnace and converter linings.
[b] Ferrosilicon included under silica brick.
[c] Furnace and converter linings included under ferrosilicon.
[d] Includes Alabama, Illinois, Minnesota, Montana, New York, and South Dakota.

More than 77 per cent of the total quantity produced was used in the manufacture of silica brick. There were 336,562,000 silica brick manufactured in 1918, but these were not all made from ganister, as a considerable quantity of silica (sand) was also used.

In 1918, 64 plants reported operations, 36 of which were in Pennsylvania, 6 in Wisconsin, 5 in Colorado, and 3 in Ohio; and the remaining plants were in 10 other States, in none of which were there more than two companies.

Pennsylvania produced 77 per cent of the total output in 1917 and 66 per cent in 1918, Pennsylvania's production for the last three years being as follows:

Ganister sold in Pennsylvania, 1916–1918.

Year.	Quantity (short tons).	Value.	Average price per ton.
1916	675,424	$410,541	$0.61
1917	1,901,630	1,114,696	1.11
1918	858,374	1,142,202	1.33

These figures show an increase in quantity of 48 per cent in 1917 and a decrease of 14 per cent in 1918. The value, however, increased 171 per cent in 1917 and 2.5 per cent in 1918. About 80 per cent of Pennsylvania's total output in 1918 was used in the manufacture of brick, of which 233,143,000 were manufactured in 1918. About 17 per cent of the ganister went for furnace and converter linings and about 6 per cent for ferrosilicon.

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Pennsylvania is the largest producer of each ganister product, 36 plants reporting operations in 1918, of which 4 were new. One plant that was working in 1917 was idle in 1918. Huntingdon County produced 417,252 short tons, valued at $517,915, of which all but a very small part, sold for furnace and converter linings, was used for silica brick. Blair County produced 262,079 short tons, valued at $364,832, of which 209,809 short tons, valued at $281,960, was used for silica brick, and the remainder, except a small quantity used for furnace and converter linings, went into ferrosilicon. Bedford County, with an output of 105,347 tons, valued at $128,654, used a small quantity for ferrosilicon and about equal quantities for silica brick and furnace and converter linings. The remainder of the output of Pennsylvania came from Carbon, Center, Fayette, Lancaster, Lawrence, Mercer, Mifflin, Montgomery, and Somerset counties.

The production of ganister in Wisconsin, where six plants were in operation, increased 24 per cent in quantity and 82 per cent in value in 1918. Practically all the output was used in making silica brick, a small portion being used for furnace and converter linings. All the material used for making silica brick was shipped out of the State as there are no manufacturers of this product in Wisconsin. The producing localities were Grand Rapids, Wood County; and Ableman, Devils Lake, and North Freedom, Sauk County.

Ohio, the third largest producer, reported sales of 48,019 tons of stone, valued at $102,447, all used for furnace and converter linings. This stone, unlike that produced in the other States reporting sales of ganister, is not quartzite but the well-known sandstone of northern Ohio, used principally as a building stone or for making grindstones. The producing localities were Berea, Cuyahoga County; Leavittsburg, Trumbull County; and Amherst and North Amherst, Lorain County. This is the first time that the total production of this stone for this use has been reported for this State.

Colorado, the only other State whose output can be reported separately, produced 43,051 short tons, valued at $56,163, in 1918. These figures show an increase of 22 per cent in quantity and 75 per cent in value over 1917. This stone all came from the vicinity of Canon City, Fremont County, and from Stone City, Pueblo County. More than half of the product is used for silica brick and most of the remainder is sold to steel plants for furnace lining, only a small portion being used in the manufacture of ferrosilicon.

The production of ganister in Illinois, South Dakota, Tennessee, and West Virginia increased in both quantity and value, and that of Alabama and New York decreased. Minnesota, for the first time, reported the sale of blocks for furnace and converter linings from the quarries at Sandstone, Pine County. The material quarried near Rock Run, Cherokee County, Ala., was used in the manufacture of fire brick. Illinois produced a cherty rock, locally called "novaculite," in Elco and Tamms, Alexander County, which was used in the manufacture of silica brick. The product of Maryland came from the vicinity of Cresaptown, Allegany County, and was used in the manufacture of ferrosilicon. The quarry at Bloomington, Garrett County, was idle in 1918. In New York ganister was quarried near Johnstown, Fulton County, and was used in the

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manufacture of ferrosilicon. The product of South Dakota was quarried near Sioux Falls, Minnehaha County, and was used about equally in the manufacture of silica brick and ferrosilicon, though a quantity of cut jasper was sold for furnace and converter linings. Tennessee produced a small quantity of ganister in the neighborhood of Alton Park, Hamilton County, which was used for furnace lining. West Virginia more than tripled its production in 1918, and the value of its product was nearly six times as much as in 1917. It was quarried at Great Cacapon and Berkeley Springs, Morgan County, and was used in the manufacture of silica brick and ferrosilicon. Montana for the first time reported a production of sandstone for use as furnace or converter lining from quarries at Field, Cascade County. Quartzite, used for furnace or converter lining was quarried at Ranger and Kinsey, Cherokee County, N. C., and shipped to Tennessee.

CRUSHED STONE.

Crushed sandstone in 1918, for the fourth year in succession, decreased in sales—42 per cent in quantity and 25 per cent in value. The largest decrease was in crushed stone for concrete, which declined about 46 per cent in quantity and 25 per cent in value.

The average price increased from $0.92 in 1917 to $1.19 in 1918. About one-fourth of the quantity sold was quarried in Pennsylvania, 221,733 short tons, valued at $256,448. North Carolina, whose output was chiefly used in the construction of a dam, stood third in quantity, but second in value; Massachusetts stood fourth in quantity, but third in value; and California stood second in quantity, but fourth in value.

BLUESTONE.

The bluestone industry of eastern New York and northeastern Pennsylvania, which was at one time of considerable importance, has almost entirely ceased. The value of bluestone quarried and sold in 1918 was $221,114. In 1911 the value of the bluestone produced was $1,876,473. Bluestone was chiefly used for curbing, flagging, and for sills, lintels, and other trimming on buildings and has been replaced largely by cement. It is very doubtful that any revival of this industry will take place, unless called for by some unusual local demand. The following tables show the condition of this industry for the last eight years:

Value of bluestone sold in the United States, 1911–1918.

Year.	Value.	Year.	Value.
1911	$1,876,473	1915	$641,446
1912	1,505,763	1916	510,011
1913	1,280,862	1917	427,896
1914	1,086,699	1918	221,114

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Value of bluestone sold in New York and Pennsylvania in 1917 and 1918.

State.	Building stone.	Flagging.	Curbing.	Other uses.[a]	Total value.
1917.					
New York	$130,056	$45,778	$150,025	$8,212	$334,071
Pennsylvania	40,266	25,901	26,408	1,250	93,825
	170,322	71,679	176,433	9,462	427,896
1918.					
New York	55,020	25,084	102,685	8,891	191,680
Pennsylvania	(b)	17,097	9,894	2,443	29,434
	55,020	42,181	112,579	11,334	221,114

[a] Includes crushed stone, rubble, riprap, and unspecified; also building stone for Pennsylvania in 1918.
[b] Included under "Other uses."

MISCELLANEOUS STONE.

The separation under the heading "miscellaneous stone" of certain different kinds, which for convenience had been included in former reports with the class of stone to which they were most nearly related, was begun in 1917 and a continuance of separation in 1918 permits a comparison for the two years. In 1918 four States—Idaho, Arkansas, Virginia, and Wisconsin—were added to those producing miscellaneous stone. The kinds of stone included under this heading are light-colored volcanic rocks (Massachusetts, North Carolina, South Dakota, Colorado, Arizona, California, Oregon); conglomerate and "grit" (Massachusetts, New York, Pennsylvania, and Virginia); slate and argillite (Massachusetts, New Jersey, Pennsylvania); chert and cherty limestone or "flint rock" (Arkansas, Florida, Missouri, Oklahoma); taconite or "iron ore rock" (Michigan; mica schist (New Hampshire, Rhode Island, Pennsylvania).

LIGHT-COLORED VOLCANIC ROCKS.

The light-colored volcanic rocks include principally rhyolite, trachyte, and andesite (chiefly lava flows) and related tuffs, or consolidated volcanic ash. Other rocks that would be included in this subgroup are dacite, phonolite, and some basaltic tuffs of light color. Any one of these rocks, except the tuffs, whether in flows or dikes, may be locally termed porphyry, if it contains distinct crystals scattered through a relatively fine grained or dense groundmass. These rocks differ considerably in physical properties, according to differences in their mode of origin and subsequent alteration. Some, particularly rhyolites, which are quarried to a considerable extent for crushed stone in eastern Massachusetts, at one place in North Carolina, and in certain parts of California, are hard and of flinty character; others, quarried mainly for local use as building stone in Colorado, South Dakota, and States west of the Rocky Mountains, are comparatively soft and in some places have been called sandstones, owing to their general resemblance to sandstone when placed in buildings, and, as regards the tuffs, to their mode of occurrence. In some regions soft light volcanic tuffs, called "trass," has been quarried for such refractory uses as fireplaces, stove linings, and chimneys.

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CONGLOMERATE AND "GRIT."

Conglomerate, or "puddingstone," is quarried in the vicinity of Boston, Mass., and formerly supplied a considerable local demand for building stone; but for several years it has been quarried mainly for crushed stone. Conglomerate is also quarried near Otisville, Orange County, N. Y. The Rensselaer "grit," a dark, hard sandstone, resembling diabase in appearance and physical properties, is quarried at Brainard, Rensselaer County.

SLATE AND ARGILLITE.

A massive slate with no indication of true slaty cleavage has also supplied former demands for building stone and present demands for crushed stone in the vicinity of Boston. At present it is quarried at Somerville and Watertown, Mass. Argillite, which supplies a considerable quantity of crushed stone in New Jersey and eastern Pennsylvania, is a shale hardened through the influence of intruding masses of igneous rock into a dark-gray to black stone, which rather closely resembles diabase or basalt (trap rock) in appearance and physical properties.

CHERT AND CHERTY LIMESTONE.

Cherty limestone, or flint rock, also lumps of chert or flint left by the weathering of these limestones are crushed for road metal and railroad ballast in Florida, Missouri, and Oklahoma.

TACONITE.

Taconite, or "iron ore rock," is a cherty or jaspery rock closely associated with iron ores in the Lake Superior region. In some places it is calcareous and in others quartzitic. Small quantities of this rock have been taken from the waste dumps of mines in Michigan and crushed for road metal.

SALES.

The total sales of miscellaneous stone in 1918 amounted to 844,740 short tons, valued at $973,034. This was a decrease of 2 per cent in the total value and of 32 per cent in quantity. The sales for different uses in 1918 are summarized in the first of the following tables, and sales itemized so far as possible by States are shown in the third.

Miscellaneous varieties of stone sold in the United States in 1918.

Use.	Quantity.	Value.
Building stone (rough and dressed).....cubic feet..	128,387	$38,979
Approximate equivalent in short tons.....	10,000	.....
Riprap.....short tons..	20,857	12,945
Crushed stone.....do....	743,292	738,486
Refractory stone.....do....	36,446	114,611
Other.....do....	34,144	68,013
	844,740	973,034

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Miscellaneous varieties of stone sold in the United States in 1917, by States.

State.	Building (value).	Crushed stone.						Other (value).	Total value.
		Road metal.		Railroad ballast.		Concrete.			
		Quantity. (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.		
Arizona	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	$37,627
California	(a)	145,489	$108,765	56,907	$18,867	102,239	$62,416	$20,704	210,812
Colorado	(a)							(a)	(a)
Florida		(a)	(a)	(a)	(a)			(a)	(a)
Massachusetts	$6,934	128,508	134,106			94,675	100,610	(a)	241,775
Michigan		(a)	(a)						(a)
Missouri		(a)	(a)						(a)
New Hampshire	(a)					(a)	(a)	(a)	(a)
New Jersey	(a)	(a)	(a)			(a)	(a)	(a)	(a)
New York		(a)	(a)	(a)	(a)	(a)	(a)		(a)
North Carolina				(a)	(a)	(a)	(a)		(a)
Oklahoma		(a)	(a)	(a)	(a)				(a)
Oregon	(a)			(a)	(a)			(a)	(a)
Pennsylvania	12,880	72,091	67,066	(a)	(a)	16,354	16,471	86,086	183,803
Rhode Island		16,403	20,154			(a)	(a)	(a)	38,554
South Dakota		(a)	(a)			(a)	(a)	(a)	(a)
Undistributed	21,451	89,352	116,353	229,310	141,306	33,718	36,016	23,458	281,071
	41,265	451,843	446,444	286,217	160,172	246,986	215,513	130,248	b993,642

a Included in "Undistributed."

b Represents 1,234,990 tons of stone.

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Miscellaneous varieties of stone sold in the United States in 1918, by States.

State.	Building.		Riprap.		Crushed stone.						Other.		Total value.
					Road metal.		Railroad ballast.		Concrete.				
	Quantity (cubic feet).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	
Arizona							(a)	(a)	(a)	(a)			(a)
Arkansas					(a)	(a)			(a)	(a)			(a)
California			20,527	$12,625	22,390	$16,438	66,736	$31,561	73,025	$59,327			$119,951
Colorado	(a)	(a)									(a)	(a)	(a)
Idaho	(a)	(a)											(a)
Florida									(a)	(a)			(a)
Massachusetts	46,000	$10,583	330	320	76,421	96,363			121,404	159,824			267,090
Michigan					(a)	(a)							(a)
Missouri					(a)	(a)							(a)
New Hampshire											(a)	(a)	(a)
New Jersey	(a)	(a)					(a)	(a)	(a)	(a)	(a)	(a)	(a)
New York					(a)	(a)	(a)	(a)					(a)
North Carolina									(a)	(a)			(a)
Oregon							(a)	(a)					(a)
Pennsylvania	36,946	20,550			17,400	22,498	(a)	(a)	55,283	64,584	41,446	$149,611	265,243
Rhode Island					30,500	45,750			3,000	4,500			50,250
South Dakota					(a)	(a)							(a)
Virginia											(a)	(a)	(a)
Wisconsin					(a)	(a)					(a)	(a)	6,125
Undistributed	45,441	7,846			41,204	59,447	126,186	60,153	109,743	118,041	29,144	33,013	264,375
	128,387	38,979	20,857	12,945	187,915	240,496	192,922	91,714	362,455	406,276	70,590	182,624	973,034

a Included in "Undistributed."

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The value of the output of Massachusetts and Pennsylvania together, in about equal proportions, represents more than one-half of the total. The stone from Massachusetts is chiefly sold as crushed stone, whereas one-half of the Pennsylvania product is sold for miscellaneous purposes, of which mica schist for refractory use forms the greater part.

About 88 per cent of the total quantity and 74 per cent of the total value of this miscellaneous stone is represented by crushed stone. The total production of crushed stone, 743,292 short tons, valued at $738,486, represents a decrease of 25 per cent in quantity and 12 per cent in value, compared with 1917. In 1918, 49 per cent of this crushed material was used for concrete, which increased 47 per cent in quantity and 89 per cent in value, due to large increases in output in Massachusetts and Pennsylvania. The stone used for road metal and railroad ballast decreased in both quantity and value.

In Virginia and in Pennsylvania a green stone is crushed into granules and used as a coating for an asphaltic felt which has been in considerable demand as a roofing material. Red and green slate granules quarried in New York and Vermont were also used in large quantities for this purpose. It is also stated that green trap rock granules from the quarries at Marquette, Mich., will be utilized for this purpose.

MICA SCHIST AS A REFRACTORY.

Sales of mica schist or "fire stone" for refractory use, mainly in the steel industry, amounted in 1918 to 36,446 short tons, a decrease of nearly 9 per cent. Its value, however, owing to increased costs of operation, was $114,611, an increase of more than 33 per cent. Sales for the last three years are as follows:

Mica schist sold for refractory uses, 1916–1918.

Year.	Quantity (short tons).	Value.
1916	33,236	$47,304
1917	39,975	85,986
1918	36,446	114,611
Percentage of change in 1918	−8.8	+33.3

This stone is quarried at Edge Hill, Ardsley, and Glenside, Pa., from steeply dipping beds of thinly foliated quartzose mica schist. A sample submitted by the Edge Hill Silica Rock Co. is yellowish white, irregularly clouded with black, and consists mainly of quartz and white mica (muscovite). The yellowish tinge is due to films of iron oxide (limonite) accompanied by a little kaolin along the foliation planes and has evidently resulted from the weathering of muscovite. The black clouding is due to small grains of ilmenite and perhaps to a little black mica and tourmaline. Partial chemical analyses show about 90 per cent of silica.

In thin sections, cut perpendicular to the foliation, quartz forms typical mosaics of interlocking elongate grains up to 1 millimeter in length. The largest mosaics are from 2 to 3 millimeters long.

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Muscovite forms typical aggregates of flakes, few groups exceeding 1 millimeter in length. Small isolated grains lie between or within quartz grains. The longer aggregates tend to fork and partly inclose quartz mosaics. Nearly all the larger muscovite aggregates are slightly stained by yellow to brown iron oxide, the iron perhaps coming from minute pyrite grains now represented by clusters of black specks. No distinct kaolinization was found, and the kaolinized flakes were apparently lost during the grinding of the section. The ilmenite forms irregular grains from 0.5 millimeter in diameter down to mere specks, some of them considerably altered to leucoxene. Titanite forms small rounded grains, some inclosed by ilmenite, others well removed from it. No tourmaline or biotite was found.

The stone, according to the producers, is used principally for lining Bessemer converters (standard and side-blow), acid open-hearth furnaces, reverbatory furnaces, air furnaces, foundry cupolas, ladles, mixers, and soaking pits, and is suited for any other furnace or vessel calling for acid lining. It is said to have lasted in Bessemer converters, in which the temperature rises to 3,500° F. (1,925° C.), for 18 months, although, as shown later, it is doubtful if more than the very surface of the stone was subjected to quite so high a temperature. It is also said to be suitable for lime and cement kilns, day and continuous tanks and pot furnaces in glass manufacture.

A sample of mica schist removed from a furnace lining after 18 months of use was also submitted by the Edge Hill Silica Rock Co. It shows at the surface a vesicular black glass or slag that has penetrated and replaced the stone for a distance of one-quarter of an inch to 1 inch. This grades into a rather porous gray zone of somewhat glassy luster and this is followed by purplish, reddish, and light-red zones, each zone about an inch thick. The mica in the light red and red zones has lost its bright silvery luster and turned to a light brown color. It is not visible in the other three zones.

Thin sections were cut from each of the five zones. That from the light-reddish zone, 5 inches from the slaggy surface, showed the quartz to be unchanged unless reduced to slightly finer grains. The muscovite was all converted to yellowish-brown to reddish material, largely amorphous and nearly opaque, but in part very finely fibrous and weakly birefringent. The color was evidently due to iron oxide which had deposited by emanations from the furnace working along the layers of dehydrated muscovite. The schistosity was preserved almost if not quite perfectly, although the altered muscovite layers appeared a little more prominent. In the section 4 inches from the surface the quartz showed no further change. The mica layers were redder and more completely isotropic. Iron was evidently present in somewhat greater quantity, but scattered bubblelike cavities in these layers suggested that a little fusion and partial volatilization of the iron-muscovite material had begun. The fusion of iron-free muscovite alone would indicate a temperature of 1200°–1300° C.,[34] but the presence of the iron, which acts as a flux, lowers the temperature of fusion appreciably. Three inches from the surface, in the purplish

[34] Doelter, C., Handbuch der Mineralchemie, Band II, 8, p. 437, 1915.

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zone, the quartz continued unchanged, but the iron oxide had partly disappeared, leaving a white opaque material. The presence of several cavities suggested partial removal of this white material by vaporization, leaving cavities bordered by rims of dark glass. The dark color of the glass was due to minute inclusions, some of them bubbles and some opaque, and relatively large scales of red iron oxide. The yellowish-gray zone, 2 inches from the surface, showed the quartz to have been appreciably replaced by glass, which encroached from the original muscovite layers and penetrated along the boundaries between the grains. Quartz alone would melt or invert to cristobalite at a temperature somewhat below 1470° C.[35], but here again the fluxing action of the glass doubtless lowered the temperature. The glassy material contained minute indeterminate inclusions as before, and also minute rod-shaped crystals, presumably sillimanite. Within an inch of the surface, the quartz was still further replaced by brownish glass or cristobalite. Any cristobalite, however, was so finely divided as to be apparently isotropic. Many grains had cracked and the cracks had been filled with the apparently isotropic material. About one-fifth of an inch (5 millimeters) from the surface a little colorless isotropic material appears replacing the quartz and in turn replaced by the brownish isotropic material. The quantity of colorless isotropic material increases toward the heated surface but had not entirely replaced the quartz, until about one-twelfth of an inch (2 millimeters) from the surface, where almost no remnants of quartz or of schistose structure remained. The glass within an inch of the surface is crowded with minute opaque specks and contains many minute groups of platy crystals, evidently cristobalite or tridymite, but still without appreciable birefringence; also more distinct though very small crystals of sillimanite, which become rapidly more abundant until within 2 millimeters of the surface they attain lengths of nearly 0.5 millimeter and the glass is thickly spangled with them. Traces of unchanged ilmenite and titanite were found 3 inches from the surface, and one titanite partly fused along fractures was found 2 inches from the surface.

The temperatures indicated by most of these changes are indefinite because of the fluxing action of minor constituents of the mica schist and of the molten iron and impurities in the furnace charge. Temperatures at which some of these changes would take place without fluxes are known, however, and may serve as an approximate indication. The change from quartz to the colorless material (cristobalite or silica glass) evidently took place without the aid of the flux, which would have produced a colored glass, and therefore would indicate a temperature somewhat below 1470° C. attained within 5 millimeters of the surface; but as this change progresses slowly in quartz that has not been finely ground, the temperature actually reached may have been somewhat higher. The eutectic mixture of the binary system silica-alumina contains about 90 per cent of silica and 10 per cent of alumina, a ratio approximated by these constituents in the mica schist. The melting point of this eutectic without fluxes is slightly

[35] Fenner, C. N., The stability relations of the silica minerals: Am. Jour. Sci., 4th ser., vol. 36, pp. 338, 383, 1913.

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below 1600° C.,[86] and with the fluxes present would be lowered to an unknown extent. The fact that the block of mica schist in question had been in use for 18 months implies that the highest temperatures to which it was subjected could not have exceeded these indicated temperatures very much.

CRUSHED STONE.

GENERAL STATISTICS.

Crushed stone which represented 43 per cent of all stone sold in 1918 decreased in production 27 per cent (10,912,035 short tons). This followed a decrease of 16 per cent in 1917, and of 2 per cent in 1916. The total sales in 1918 amounted to 29,373,342 short tons, of which 65 per cent represented limestone, 22 per cent basalt and related rocks (trap rock), 7 per cent granite, and 6 per cent nearly equally divided between sandstone and miscellaneous varieties of rocks. The value of the crushed stone sold was $27,951,393, a decrease of nearly 4 per cent ($1,114,116). This is the lowest value recorded for crushed stone since 1910, and the quantity represents the smallest output since 1906. The average price was 95 cents in 1918, an increase of 23 cents over 1917 and of 34 cents over 1916. The change in total average per short ton of crushed stone since 1905 is seen in the following table:

Average price per short ton of crushed stone, 1905–1918.

Year.	Road metal.	Railroad ballast.	Concrete.	Total crushed stone.
1905	$0.64	$0.48	$0.67	$0.59
1906	.64	.49	.65	.59
1907	.66	.52	.71	.63
1908	.62	.52	.65	.61
1909	.67	.48	.64	.61
1910	.62	.48	.64	.59
1911	.62	.50	.65	.59
1912	.60	.49	.67	.59
1913	.63	.51	.67	.61
1914	.61	.51	.68	.61
1915	.60	.50	.65	.60
1916	.63	.49	.67	.61
1917	.75	.56	.78	.72
1918	.97	.77	1.05	.95

There has been no increase or decrease of more than 2 cents a ton in total average price except in the year 1907 (increase of 4 cents) until 1917, when increased cost of supplies and labor caused an increase of 11 cents. The average price of the different uses of stone showed a somewhat wider range of difference, but with no decided change until 1917.

Crushed stone is used principally for road metal, railroad ballast, and concrete. The concrete is used in building and construction work, for curbing and flagging, for stucco, and has found increased use in the last few years in the building of roads. The largest decrease in quantity in 1918 was stone used for road metal (36 per cent)

[86] Shepherd, E. S., and Rankin, G. S., The binary systems of alumina with silica, lime, and magnesia: Am. Jour. Sci., 4th ser., vol. 28, p. 301, 1909.

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and the smallest in railroad ballast (15.5 per cent). Concrete decreased 25 per cent. Railroad ballast was the only use for which any considerable increase in value was given (16 per cent) but neither this increase nor the small increase (1 per cent) in the value of concrete, was enough to offset in the total value the decrease of nearly 18 per cent in the value of road metal. The only crushed-stone products which showed increase in quantity were basalt and related rocks (trap rock) used for railroad ballast, which increased less than 1 per cent, and miscellaneous stone for concrete, which increased 46 per cent.

Crushed granite, the sales of which in 1918 amounted to 2,069,473 short tons, valued at $2,583,449, decreased 32 per cent in quantity and 4 per cent in value. Basalt, the sales of which as crushed stone, amounted to 6,556,888 short tons, valued at $7,306,168, decreased 19 per cent in quantity but increased about 11 per cent in value. Sandstone, of which 882,831 short tons, valued at $1,050,106, was sold, decreased 42 per cent in quantity and 25 per cent in value. Limestone, of which 19,120,858 short tons, valued at $16,273,184, was sold, decreased 28 per cent (7,525,784 short tons) in quantity but only 7 per cent ($1,267,914) in value. The quantity of miscellaneous varieties of stone sold as crushed stone was 743,292 short tons, valued at $738,486, a decrease of 25 per cent in quantity and 12 per cent in value.

PRODUCTION BY STATES.

Crushed stone was produced in 47 States in 1918, as in 1917, although Idaho appeared among the crushed stone States and Nevada dropped out of the list. Of the States whose production is shown separately in the accompanying tables, only three, Georgia, South Carolina, and Tennessee, showed increase in both quantity and value. Tennessee's increase was in road metal and concrete, and Georgia's and South Carolina's in concrete. It is noteworthy that the only three increases in quantity should be in States in the same section of the country. Of the remaining States, 23 decreased in both quantity and value and 11 showed increased value. In 1911, 8 States produced more than 1,000,000 short tons each of crushed stone, compared with 14 in 1917.

Ohio, New York, and Illinois, with outputs of 3,987,249, 2,841,200, and 2,802,090 short tons, respectively, were the largest producers, representing, as in 1917, a little over 32 per cent of the total. In 1917 Illinois produced 4,528,572 short tons, New York 4,293,831 short tons, and Ohio 4,156,321 short tons. Ohio regained first place lost in 1917 and Illinois dropped to third. The decrease in Illinois of 1,726,482 short tons (38 per cent) was nearly 73 per cent for concrete and 23 per cent for road metal. New York's decrease was 1,452,631 short tons (34 per cent), of which 41 per cent was for road metal, 55 per cent for concrete, and 4 per cent for railroad ballast. The decrease in Ohio was only 169,072 short tons (4 per cent), which represented a decrease of 227,909 tons for road metal and 19,130 tons for concrete and a gain of 77,967 tons for railroad ballast. Illinois showed decrease in total value and Ohio and New York showed

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increase. Other States showing decreases of over 400,000 tons in output of crushed stone were California, Connecticut, Indiana, Kentucky, Missouri, New Jersey, Pennsylvania, and Virginia.

Practically all road construction was discontinued in 1917 and 1918 except that necessary for repairing roads worn out by unusually heavy traffic, and the building of roads required for the transportation of war essentials. This applied to roads in the neighborhood of Army and Navy cantonments, newly established manufacturing and construction plants, and large cities which were either railroad or water transportation centers. In the meantime many of the roads in the interior or off the main line of transportation suffered either for necessary repairs or construction was discontinued for lack of labor and necessary appropriations to carry on the work. After the signing of the armistice plans were immediately made for resumption of road building and repairing, and a program inaugurated for the opening of the country by new highways, especially in the West and Northwest, which if carried out will start in 1919 the beginning of road construction that will require increased output of road material for several years, and probably continue indefinitely. A special rate was given by the Railroad Administration on crushed stone shipped for municipal work. The production of stone for concrete should also increase with the demand for road material, as concrete-road construction is becoming more and more used by road contractors. The smaller decrease in percentage of crushed stone used for railroad ballast than for either concrete or road metal is easily explained by the necessity of keeping road beds in condition to carry the enormously increased traffic, especially that coming to eastern seaports for shipment abroad, as indicated by the increased production of basalt and related rocks in Massachusetts, New Jersey, New York, and Pennsylvania.

A considerable quantity of sand, gravel, "chats" or tailings from the zinc mines in Missouri and Kansas, chert, slag, and waste from iron mines is used for road metal, railroad ballast, and concrete, roofing gravel, and other purposes supplied by ordinary crushed stone. The quantity and value of this material is not included in the figures given in this report.

According to H. A. Buehler, State geologist of Missouri, the quantity of "chats" shipped from zinc mines in 1918 amounted to 902,129 short tons, a decrease of 524,587 short tons (37 per cent), and followed a decrease of 1,464,254 short tons (50 per cent) in 1916. Nearly 70 per cent of this material was taken by the railroads of southeastern and southwestern Missouri, and the remainder was sold commercially. It is believed that most of the material was used for railroad ballast. The gravel sold in 1918 for the same uses as crushed stone amounted to 20,640,101 short tons, valued at $11,791,073, a decrease of 18 per cent in quantity but a slight increase in total value. Railroads also reported the production for their own use of 8,064,505 short tons of sand and gravel, valued at $1,772,237, a decrease of 27 per cent in quantity but an increase in value. Further details of the crushed-stone industry are shown in the following tables, and in figures 115, 116, and 117.

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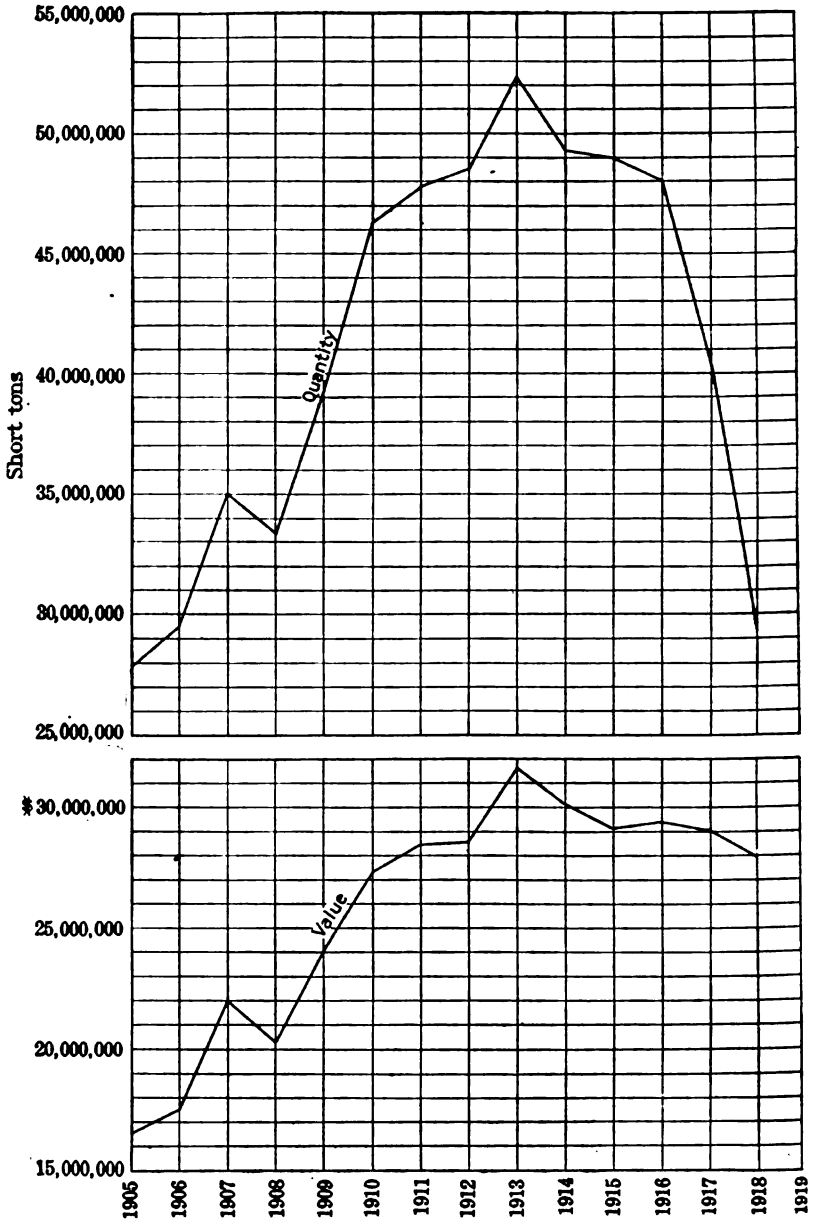

FIGURE 115.—Total quantity and value of crushed stone sold, 1905–1918. For total value in 1898–1904, see Pls. X and XII.

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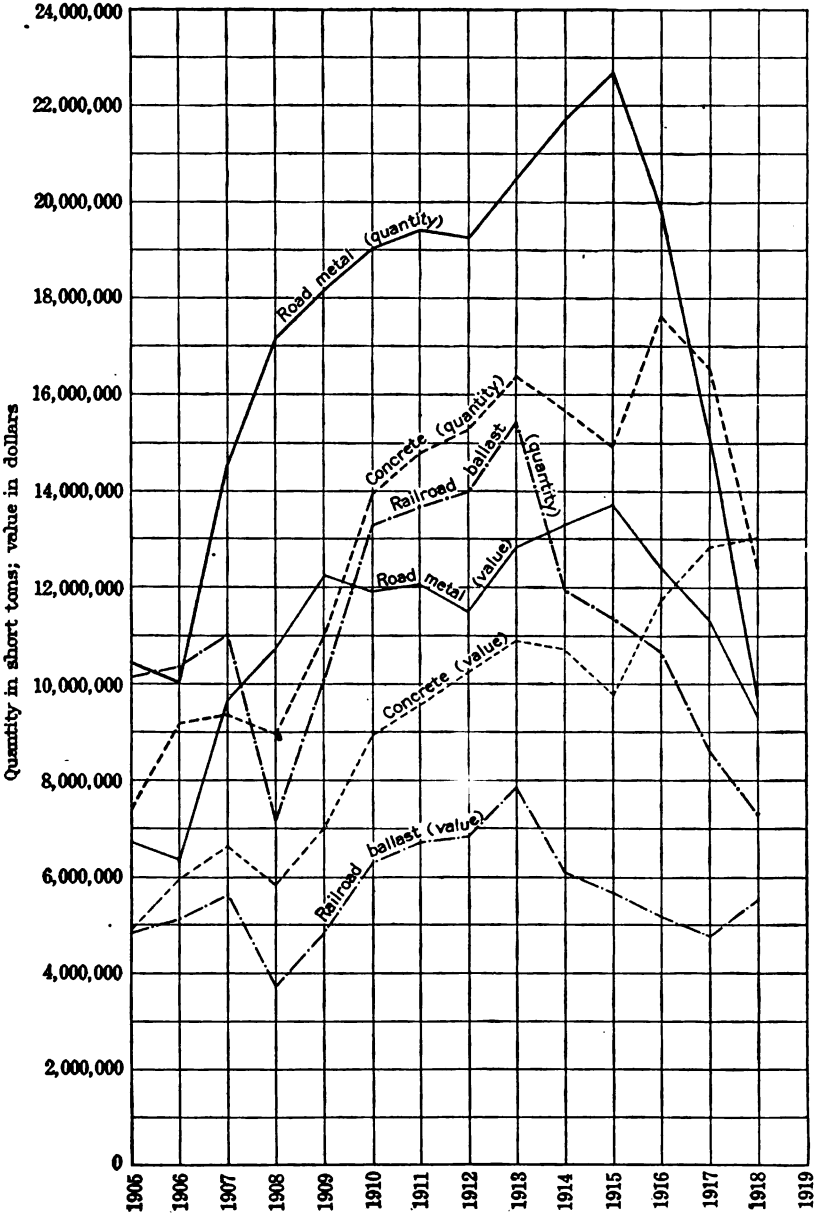

FIGURE 116.—Quantity and value of crushed stone for different uses, 1905–1918.

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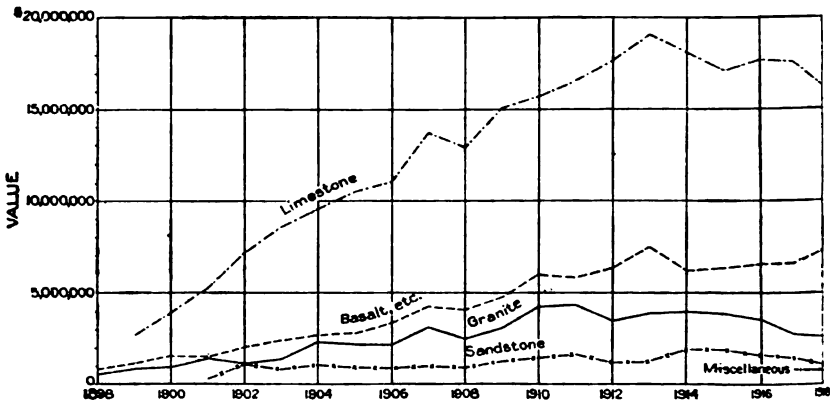

FIGURE 117.—Value of limestone, basalt, granite, and sandstone sold as crushed stone, 1898–1918.

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Crushed stone sold in the United States in 1917, by States.

State.	Road metal.		Railroad ballast.		Concrete.		Total.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Alabama	11,400	$14,170	.....	.....	75,502	$54,368	86,902	$68,538
Arizona	6,466	9,350	(a)	(a)	(a)	(a)	121,631	47,146
Arkansas	252,773	213,495	123,818	$69,326	17,744	14,556	394,335	297,377
California	994,459	596,424	252,429	123,526	1,549,467	985,592	2,796,355	1,705,542
Colorado	.....	.....	.....	.....	(a)	(a)	(a)	(a)
Connecticut	865,200	480,414	158,005	119,597	394,551	339,365	1,417,756	939,376
Delaware	(a)	(a)	.....	.....	(a)	(a)	40,966	53,863
District of Columbia	(a)	(a)	.....	.....	(a)	(a)	(a)	(a)
Florida	247,697	196,161	214,522	173,857	57,811	83,517	520,030	453,535
Georgia	62,816	51,554	21,921	16,483	128,391	134,289	213,128	202,326
Hawaii	.....	.....	.....	.....	129,126	165,665	214,007	254,747
Illinois	1,155,749	664,887	745,901	342,224	2,626,922	1,494,237	4,528,572	2,501,348
Indiana	1,136,653	684,289	262,647	115,721	78,641	50,654	1,477,941	850,664
Iowa	43,262	44,744	8,529	5,771	499,221	339,622	551,012	390,137
Kansas	165,861	126,057	213,645	137,274	298,804	292,202	678,310	554,533
Kentucky	522,685	384,887	701,881	339,085	164,070	95,926	1,388,636	819,898
Louisiana	.....	.....	(a)	(a)	(a)	(a)	(a)	(a)
Maine	(a)	(a)	.....	.....	(a)	(a)	(a)	(a)
Maryland	384,102	405,017	100,889	65,756	264,790	233,611	749,781	704,384
Massachusetts	603,793	647,535	10,949	10,885	494,818	532,001	1,109,560	1,190,421
Michigan	794,812	433,473	182,375	90,560	422,965	250,172	1,400,152	774,155
Minnesota	43,831	44,978	13,472	11,290	390,040	351,855	447,343	408,123
Missouri	254,648	210,826	170,362	102,906	626,295	605,734	1,051,305	919,466
Montana	(a)	(a)	(a)	(a)	39,004	27,440	45,462	30,917
Nebraska	34,398	24,886	23,339	18,292	324,504	348,173	382,241	391,351
Nevada	.....	.....	(a)	(a)	.....	.....	(a)	(a)
New Hampshire	33,660	35,152	.....	.....	4,577	4,984	38,237	40,136
New Jersey	893,335	886,882	178,065	149,206	403,395	408,770	1,474,815	1,444,858
New Mexico	.....	.....	(a)	(a)	(a)	(a)	(a)	(a)
New York	1,503,914	1,038,461	825,653	538,671	1,964,264	1,524,551	4,293,831	3,101,683
North Carolina	110,568	113,654	76,348	51,962	475,268	565,605	662,184	731,221
Ohio	1,869,282	1,182,796	1,053,710	490,436	1,233,329	717,010	4,156,321	2,390,242
Oklahoma	33,042	26,327	568,012	327,621	324,040	236,133	925,094	590,081
Oregon	124,820	95,449	35,958	7,677	121,954	103,081	282,732	206,207
Pennsylvania	985,651	1,138,900	791,338	611,494	1,069,492	943,245	2,846,481	2,693,639
Rhode Island	40,261	56,788	.....	.....	21,500	29,275	61,761	86,063
South Carolina	5,494	5,100	(a)	(a)	223,222	287,541	241,224	301,295
South Dakota	16,161	12,284	.....	.....	100,766	93,489	116,927	105,773
Tennessee	295,332	237,569	428,233	156,169	197,433	123,590	920,998	517,328
Texas	62,636	49,875	168,904	68,202	452,423	317,785	683,963	435,862
Utah	.....	.....	.....	.....	(a)	(a)	(a)	(a)
Vermont	6,607	3,388	(a)	(a)	8,313	9,118	15,920	13,756
Virginia	562,962	544,566	822,970	432,014	273,614	187,677	1,659,546	1,164,257
Washington	58,975	36,054	.....	.....	41,545	33,233	100,520	69,287
West Virginia	227,816	132,693	186,982	86,872	175,883	130,070	590,681	349,635
Wisconsin	595,577	460,172	30,325	23,338	736,696	615,011	1,362,598	1,098,521
Wyoming	.....	.....	.....	.....	(a)	(a)	(a)	(a)
Undistributed	96,858	102,303	233,841	108,208	166,398	151,429	236,119	167,818
	15,103,556	11,390,560	8,605,043	4,794,423	16,576,778	12,880,526	40,285,377	29,065,509

a Included in "Undistributed."

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Crushed stone sold in the United States in 1918, by States.

State.	Road metal.		Railroad ballast.		Concrete.		Total.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Alabama	(a)	(a)	.....	.....	21,749	$23,548	(a)	(a)
Arizona	.....	.....	(a)	(a)	(a)	(a)	81,362	$54,041
Arkansas	169,470	$191,743	132,424	$112,572	69,939	97,668	371,833	401,983
California	747,185	483,949	247,379	142,714	1,219,709	886,331	2,214,273	1,512,994
Colorado	.....	.....	(a)	(a)	(a)	(a)	11,461	15,603
Connecticut	337,900	321,591	91,898	93,504	451,933	431,534	881,731	846,629
Delaware	(a)	(a)	.....	.....	(a)	(a)	(a)	(a)
District of Columbia	(a)	(a)	.....	.....	(a)	(a)	(a)	(a)
Florida	19,646	16,356	(a)	(a)	(a)	(a)	294,762	268,478
Georgia	40,635	78,158	20,663	35,660	158,294	237,950	219,592	351,768
Hawaii	63,273	75,257	.....	.....	97,753	140,836	161,026	216,093
Idaho	(a)	(a)	.....	.....	(a)	(a)	(a)	(a)
Illinois	748,592	489,360	717,520	457,144	1,335,978	964,140	2,802,090	1,910,644
Indiana	498,901	397,964	128,316	65,187	145,889	109,304	773,106	572,455
Iowa	(a)	(a)	(a)	(a)	211,404	192,869	262,237	245,048
Kansas	15,447	15,361	94,801	87,733	278,379	279,467	388,627	382,561
Kentucky	315,573	355,814	527,454	371,085	78,627	73,744	921,654	800,643
Louisiana	.....	.....	.....	.....	(a)	(a)	(a)	(a)
Maine	(a)	(a)	(a)	(a)	14,886	17,983	18,447	22,281
Maryland	148,972	233,961	96,915	124,703	267,447	382,366	513,334	741,030
Massachusetts	507,730	687,126	4,405	5,955	394,313	605,065	906,448	1,298,146
Michigan	(a)	(a)	(a)	(a)	392,865	266,837	1,225,740	697,643
Minnesota	(a)	(a)	(a)	(a)	293,220	369,449	327,164	411,888
Missouri	170,876	199,601	155,110	110,494	319,044	356,582	645,030	666,677
Montana	20,486	18,465	(a)	(a)	(a)	(a)	32,516	26,390
Nebraska	(a)	(a)	(a)	(a)	180,802	218,771	197,785	238,277
New Hampshire	(a)	(a)	.....	.....	(a)	(a)	17,083	26,024
New Jersey	442,378	629,654	235,517	285,402	381,287	582,902	1,059,182	1,497,958
New Mexico	.....	.....	(a)	(a)	(a)	(a)	113,322	84,874
New York	899,836	893,271	770,603	781,955	1,170,761	1,656,900	2,841,200	3,332,126
North Carolina	36,270	55,518	69,912	77,651	451,359	644,839	557,541	778,008
Ohio	1,641,373	1,363,703	1,131,677	684,585	1,214,199	872,466	3,987,249	2,920,754
Oklahoma	22,097	24,483	409,145	334,050	223,947	219,194	655,189	577,727
Oregon	62,056	62,701	64,101	16,058	80,073	77,969	206,230	156,728
Pennsylvania	717,813	944,654	604,663	641,679	900,198	1,121,632	2,222,674	2,707,965
Rhode Island	45,140	68,406	.....	.....	3,500	5,150	48,640	73,556
South Carolina	(a)	(a)	.....	.....	(a)	(a)	254,540	467,120
South Dakota	(a)	(a)	(a)	(a)	12,145	13,469	36,704	39,078
Tennessee	309,041	243,774	327,962	130,528	308,051	265,291	945,054	639,593
Texas	154,642	120,330	39,557	21,627	340,661	288,328	534,860	430,285
Utah	(a)	(a)	.....	.....	(a)	(a)	(a)	(a)
Vermont	2,625	3,997	.....	.....	13,285	22,425	15,910	26,422
Virginia	202,251	248,012	581,511	456,427	372,684	409,393	1,156,446	1,113,832
Washington	(a)	(a)	(a)	(a)	26,969	23,779	56,699	53,638
West Virginia	113,962	154,670	137,361	92,686	82,032	102,332	333,355	349,688
Wisconsin	295,771	290,628	29,704	19,841	517,425	479,500	842,900	789,969
Wyoming	.....	.....	.....	.....	(a)	(a)	(a)	(a)
Undistributed	946,506	701,164	651,117	421,409	376,373	571,060	238,356	204,776
	9,696,447	9,369,671	7,269,715	5,570,649	12,407,180	13,011,073	29,373,342	27,951,393

a Included in "Undistributed."

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Total crushed stone sold in the United States, 1913–1918.

Year.	Quantity. (short tons).	Value.
1913	52,318,965	$31,677,871
1914	49,364,476	30,161,766
1915	49,008,709	29,173,488
1916	48,075,581	29,462,552
1917	40,285,377	29,065,509
1918	29,373,342	27,951,393

Crushed stone sold in the United States in 1917 and 1918, by kinds of stone.

	Road metal.		Railroad ballast.		Concrete.		Total.		Average price per ton.
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	
1917.									
Granite	1,176,557	$1,001,076	478,667	$269,218	1,409,902	$1,430,326	3,065,126	$2,700,620	$0.88
Basalt and related rocks (trap rock)	3,751,396	3,124,088	1,019,475	822,459	3,296,711	2,654,410	8,067,582	6,600,957	.82
Limestone	9,273,282	6,420,257	6,579,905	3,394,495	10,793,455	7,726,346	26,646,642	17,541,098	.66
Sandstone	450,478	398,695	240,779	148,079	829,724	853,931	1,520,981	1,400,705	.92
Miscellaneous	451,843	446,444	286,217	160,172	246,986	215,513	985,046	822,129	.72
	15,103,556	11,390,560	8,605,043	4,794,423	16,576,778	12,880,526	40,285,377	29,065,509	.....
Average price per ton	.....	$0.75	.....	$0.56	.....	$0.78	.....	$0.72	.....
1918.									
Granite	677,292	799,720	371,900	330,222	1,020,281	1,453,507	2,069,473	2,583,449	$1.25
Basalt and related rocks (trap rock)	2,484,840	2,882,274	1,023,440	1,104,047	3,048,608	3,319,847	6,556,888	7,306,168	1.11
Limestone	6,085,337	5,177,501	5,509,911	3,901,682	7,525,610	7,194,001	19,120,858	16,273,184	.85
Sandstone	261,063	269,680	171,542	142,984	450,226	637,442	882,831	1,050,106	1.19
Miscellaneous	187,915	240,496	192,922	91,714	362,455	406,276	743,292	738,486	.99
	9,696,447	9,369,671	7,269,715	5,570,649	12,407,180	13,011,073	29,373,342	27,951,393	.....
Average price per ton	.....	$0.97	.....	$0.77	.....	$1.05	.....	$0.95	.....
Percentage of increase or decrease for 1918.	−35.8	−17.7	−15.5	+16.2	−25.2	+1.0	−27.1	−3.8	.....

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COAL—PART B, DISTRIBUTION AND CONSUMPTION.

By C. E. LESHER.

INTRODUCTION.

SOURCE OF INFORMATION.

The intensive study of the distribution and consumption of coal in 1918 by the Fuel Administration has made available a wealth of data on these important subjects, and the statistics presented in this report are largely drawn from the records of the Bureau of Statistics of the Fuel Administration, for the work of which the writer was responsible. The data collected in 1918 were in very great detail but did not represent a 12-month period. The field offices of the Fuel Administration were not completely organized until April, 1918, and much of the information used in the report of the bureau cited dates from that time. It has been necessary to recompile much of the material and reduce it to an annual basis and to collect some additional figures in order to obtain statistics comparable in form and scope to those presented in the corresponding chapter of Mineral Resources for 1917.

Complete and absolutely accurate reports of distribution are impossible to obtain, and any attempt to compile such statistics as are given in this report must include estimates, but it is believed that the data for 1918 are more nearly accurate than those given in the reports for 1915 and 1917, and that they are thoroughly reliable in all important aspects. The reader is referred to the report of the Distribution Division of the Fuel Administration, Parts I and III, for greater detail than is found in this summary.

UNIT OF MEASUREMENT.

The net ton of 2,000 pounds has been used as the unit of measurement throughout this report.

ACKNOWLEDGMENTS.

The writer is deeply indebted to Mr. Wayne P. Ellis, formerly assistant director of the Bureau of Statistics of the Fuel Administration, for the major portion of the statistical compilations in this report.

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DISTRIBUTION OF BITUMINOUS COAL AND LIGNITE.

GENERAL FEATURES.

The statistics collected from the operators of coal mines and published in Part A of this report show the quantities of bituminous coal and lignite (1) used at the mines for generating steam and heat, (2) sold locally or used by employees, (3) used at the mines for making coke (none of this coal is shipped), and (4) shipped to market, either by rail or by river. The destination and use of the coal embraced in the first three items are thus recorded, but a special investigation was necessary to determine the destination and use of the coal shipped, which forms 86 per cent of the quantity produced.

Coal reaches the market by three general methods of transportation—(1) all rail, with which in this report are included the shipments by rivers; (2) rail to tidewater, thence by vessel to foreign markets (exports), or by vessel to other points on the coasts of the United States or its insular possessions (coastwise), or used at tidewater points for fuel on steamships (bunker); (3) rail to the Great Lakes, notably to lower Lake ports on Lake Erie, thence by boat to upper Lake ports on Lake Superior or Lake Michigan or to Canada, and from upper Lake ports again by rail to markets in the interior.

The statistics in this report show the coal consumed in each State for domestic and industrial purposes, by public utilities, both gas and electric, and by manufacturers of coke. Coal used by railroads is not shown by States but by classes of roads and by the three large recognized districts in the country.

The all-rail movement, which, as has been explained, includes shipments by rivers, is separated into (1) shipments to points within the State in which the coal was mined, with which, for convenience, are included quantities not shipped, used at the mines for steam and heat and used locally and by employees at the coal mines; (2) shipments to other States; (3) quantities used by railroads serving the coal fields or delivered by them to other railroads; and (4) exports to Canada and Mexico by rail. The details of the shipments to other States and of the tidewater and Lake movements are given in succeeding tables.

DISTRIBUTION BY ALL-RAIL ROUTES.

About 96 per cent of the bituminous coal produced in the United States is used in this country, and more than 86 per cent of the total output reaches the consumers by all-rail delivery. The States in which the coal is mined are the largest consumers, having used 36 per cent of the total output in 1918. The railroads received by all-rail delivery 149,408,000 tons, or 25 per cent of the total, in addition to which the roads in New England and the roads in the Northwest received about 9,000,000 tons by way of tidewater and Lake and from Canada. Shipments to tidewater represented 7 per cent of the total, and shipments to the Lakes 5 per cent of the total.

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Distribution of bituminous coal produced in the United States in 1918, by routes and destinations.

Source.		Used at mine or shipped, except to tidewater or lakes.								Shipped to tidewater.		Shipped to Great Lakes for cargo.		Total quantity (net tons).
		Used within the State.		Shipped to other States.		Used by railroads.		Exported by rail.						
State.	Field.	Quantity (net tons).	Per cent of production.	Quantity (net tons).	Per cent of production.	Quantity (net tons).	Per cent of production.	Quantity (net tons).	Per cent of production.	Quantity (net tons).	Per cent of production.	Quantity (net tons).	Per cent of production.	
Alabama	Alabama	11,627,695	60.6	1,563,467	8.2	5,207,184	27.1			786,616	4.1			19,184,962
Arkansas	Arkansas	621,916	27.9	832,537	37.4	772,916	34.7							2,227,369
California, Idaho	California and Idaho	6,400	100.0											6,400
Colorado	Colorado	6,345,806	51.1	2,790,553	22.5	3,246,855	26.2	24,357	0.2					12,407,571
Georgia	Georgia	(a)		(a)		(a)				(a)		(a)		(a)
Illinois	Illinois	37,427,705	41.9	19,382,513	21.7	32,370,362	36.3	95,125	.1	15,400				89,291,105
Indiana	Indiana	13,003,787	42.4	8,665,310	28.3	8,904,451	29.0	105,086	.3					30,678,634
Iowa	Iowa	3,819,427	46.6	475,145	5.8	3,897,623	47.6							8,192,195
Kansas	Kansas	2,341,854	31.0	1,976,661	26.1	3,243,432	42.9							7,561,947
Kentucky	Hazard	292,085	12.4	1,485,023	62.8	314,940	13.2	1,386				270,902	11.6	2,364,336
Do	Northeastern Kentucky.	1,140,472	16.0	4,452,324	62.6	585,976	8.3	125,235	1.8			804,809	11.3	7,108,816
Do	Southeastern Kentucky.	1,411,185	17.5	4,830,962	59.8	1,588,246	19.6	205		13,223	.2	238,843	2.9	8,082,664
Do	Western Kentucky	2,809,728	25.9	3,836,231	35.4	4,176,775	38.6			10,500	.1			10,833,234
Do	Kanawha and Kenova-Thacker.	618,127	2.0	(b)		(b)		(b)		(b)		(b)		618,127
Maryland	Cumberland - Piedmont and Somerset.	1,487,952	10.5	(c)		(c)		(c)		(c)				1,487,952
Michigan	Michigan	1,190,497	81.3			274,321	18.7							1,464,818
Missouri	Missouri	2,881,900	50.8	728,099	12.8	2,057,731	36.4							5,667,730
Montana	Montana and northern Wyoming.	1,695,717	22.3	d 1,388,788	18.3	d 4,183,182	55.0	d 47						7,267,734
New Mexico	New Mexico	1,403,715	34.9	679,461	16.9	1,735,832	43.2	74,231	1.8	130,000	3.2			4,023,239
North Carolina	North Carolina	1,420	100.0											1,420
North Dakota	North Dakota	691,637	96.1	14,490	2.0	13,606	1.9							719,733
Ohio	Southern Ohio	5,531,946	35.1	e 2,848,899	18.1	e 3,826,636	24.3	e 221,388	1.4			e 3,216,221	20.3	15,645,090
Do	Northern Ohio	12,198,428	40.3	2,657,295	8.8	6,939,032	22.9	2,155,893	7.1	15,523	.1	6,320,513	20.8	30,286,681
Oklahoma	Oklahoma	1,681,134	34.9	889,324	18.5	2,242,989	46.6							4,813,447
Oregon	Oregon	13,328	100.0											13,328
Pennsylvania	Central Pennsylvania	12,282,131	19.9	f 15,233,134	24.8	18,190,635	29.5	4,344,524	7.0	11,566,283	18.8	12,002		61,628,709
Do	Northern Pennsylvania.	2,551,062	31.7	2,555,657	31.7	2,087,382	25.9	711,745	8.9			145,537	1.8	8,051,383

a Tennessee includes Georgia.
b Kanawha and Kenova-Thacker, W. Va., includes Kentucky.
c Cumberland-Piedmont, Somerset, and Meyersdale, Pa., includes Maryland and West Virginia.
d Montana and northern Wyoming includes Wyoming.
e Southern Ohio includes West Virginia.
f Includes 229,351 tons of railroad fuel via Lake Ontario.

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Distribution of bituminous coal produced in the United States in 1918, by routes and destinations—Continued.

Source.		Used at mine or shipped, except to tidewater or lakes.								Shipped to tidewater.		Shipped to Great Lakes for cargo.		Total quantity (net tons).
		Used within the State.		Shipped to other States.		Used by railroads.		Exported by rail.						
State.	Field.	Quantity (net tons).	Per cent of production.	Quantity (net tons).	Per cent of production.	Quantity (net tons).	Per cent of production.	Quantity (net tons).	Per cent of production.	Quantity (net tons).	Per cent of production.	Quantity (net tons).	Per cent of production.	
Pennsylvania..	Westmoreland, Greensburg, Latrobe, and Ligonier.	7,230,274	40.8	2,001,875	11.3	6,142,348	34.7	219,876	1.2	1,653,425	9.4	453,672	2.6	17,701,470
Do.....	Connellsville.....	28,277,368	79.3	4,149,005	11.6	2,043,219	5.7	231,300	.7	517,248	1.4	458,360	1.3	35,676,500
Do.....	Cumberland-Piedmont and Somerset.	3,128,298	21.9	[a] 2,512,764	17.6	[a] 759,010	5.3	[a] 228	.....	[a] 6,166,553	43.2	.....	.....	12,566,853
Do.....	Pittsburgh and Panhandle.	21,334,122	41.4	[b] 13,163,098	25.5	[b] 5,587,177	10.9	[b] 2,298,676	4.5	[b] 277,534	.5	[b] 7,080,162	13.7	49,740,769
South Dakota..	South Dakota.....	7,942	100.0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	7,942
Tennessee [c]....	Tennessee [c].....	2,319,370	33.6	1,367,950	19.8	3,209,223	46.6	.....	.....	1,124	.....	97	.....	6,897,764
Texas.....	Texas.....	1,222,699	54.1	6,761	.3	941,874	41.6	69,801	3.1	20,000	.9	.....	.....	2,261,135
Utah.....	Utah and southern Wyoming.	2,684,262	23.3	[d] 2,776,816	24.2	[d] 5,553,320	48.3	.....	.....	[d] 69,884	.6	.....	.....	11,084,282
Virginia.....	Southwest Virginia...	2,963,885	32.8	2,639,199	29.2	2,872,154	31.8	996	.....	564,558	6.2	.....	.....	9,040,792
Do.....	Pocahontas and Tug River.	2,071,687	8.9	[e]	.....	[e]	.....	[e]	.....	[e]	.....	[e]	.....	2,071,687
Washington....	Washington.....	1,510,782	37.0	188,026	4.6	1,871,084	45.8	20,000	.5	494,320	12.1	.....	.....	4,082,212
West Virginia..	Fairmont.....	2,727,356	13.6	5,798,315	28.8	6,364,777	31.6	155,075	.8	3,741,539	18.6	1,317,284	6.6	20,104,346
Do.....	New River.....	1,122,050	7.8	2,995,688	18.7	980,791	6.7	1,278	.....	9,286,536	64.3	361,450	2.5	14,447,793
Do.....	Pocahontas and Tug River.	3,256,169	14.1	[e] 6,581,753	28.5	[e] 1,541,063	6.7	[e] 172,443	.7	[e] 7,854,855	34.0	[e] 1,650,265	7.1	21,056,548
Do.....	Kanawha and Kenova-Thacker.	1,494,074	4.9	[f] 15,361,549	50.1	[f] 5,681,786	18.5	[f] 310,297	1.0	[f] 1,362,963	4.5	[f] 5,826,384	19.0	30,037,053
Do.....	Cumberland-Piedmont and Somerset.	212,420	1.5	(a)	.....	(a)	.....	(a)	.....	(a)	.....	.....	.....	212,420
Do.....	Pittsburgh and Panhandle.	1,813,573	3.5	(b)	.....	(b)	.....	(b)	.....	(b)	.....	.....	.....	1,813,573
Do.....	Southern Ohio.....	122,446	.8	(g)	.....	(g)	.....	(g)	.....	(g)	.....	(g)	.....	122,446
Wyoming.....	Montana and northern Wyoming.	338,394	4.4	(h)	.....	(h)	.....	(h)	.....	(h)	.....	.....	.....	338,394
Do.....	Utah and southern Wyoming.	417,608	3.6	(d)	.....	(d)	.....	.....	.....	(d)	.....	.....	.....	417,608
Alaska.....	Alaska.....	75,606	100.0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	75,606
		209,407,439	36.1	136,526,672	23.6	149,407,932	25.8	11,339,192	1.9	44,548,084	7.7	28,156,501	4.9	579,385,820

[a] Cumberland-Piedmont, Somerset, and Meyersdale, Pa., includes Maryland and West Virginia.
[b] Pittsburgh and Panhandle includes West Virginia.
[c] Tennessee includes Georgia.
[d] Utah and southern Wyoming includes Wyoming.
[e] Pocahontas and Tug River, W. Va., includes Virginia.
[f] Kanawha and Kenova-Thacker, W. Va., includes Kentucky.
[g] Southern Ohio includes West Virginia.
[h] Montana and northern Wyoming includes Wyoming.

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DISTRIBUTION OF TIDEWATER SHIPMENTS.

The quantity of bituminous coal shipped to tidewater and dumped over piers into boats either as bunker coal or as cargo in 1918 was 44,537,684 net tons. Of this total more than 95 per cent was handled at four northern Atlantic ports—Hampton Roads, Baltimore, Philadelphia, and New York.

Foreign exports by ocean vessels (offshore) from both Atlantic and Pacific ports amounted to 4,022,000 net tons, or 9 per cent of the total tidewater dumping. Coastwise shipments, mainly to New England, amounted to 27,995,000 net tons, or about 63 per cent of the total; bunker coal for vessels engaged in both foreign and domestic trade, including bunker coal taken by Navy and Army Transport Service, amounted to 12,000,000 net tons, or about 28 per cent of the total.

Distribution of tidewater shipments of coal in 1917 and 1918.

	Quantity (net tons).		Percentage of increase or decrease, 1918.
	1917	1918	
Foreign export	5,603,782	4,022,001	−39.33
Foreign bunker	6,731,539	5,420,671	−24.18
Domestic bunker	3,597,899	[a] 7,099,956	+97.33
Coastwise, inside the Capes and New York	22,607,625	27,995,056	+23.83
	38,540,845	44,537,684	+15.56

[a] Includes Navy and Army transport bunkers.

The coal fields in central Pennsylvania were in 1918 the largest shippers of bituminous coal to tidewater, mainly to New York Harbor, for use in and about New York City and for bunker coal. The New River field was the second largest shipper of coal to tidewater, reaching Hampton Roads with coal for New England and for foreign cargo and for bunker fuel. The Pocahontas and Somerset and Cumberland-Piedmont fields followed in importance, and only three other fields—Fairmont, W. Va., Greensburg-Westmoreland, Pa., and the Kanawha district of southern West Virginia—recorded more than a million tons to tidewater during the year.

More than one-fourth of the total bituminous coal dumped at tidewater was used for steamship bunker fuel and by the Navy and Army Transport Service. Exports to foreign countries represented less than 10 per cent of the total. Shipments by vessel to New England took one-third of the total, and local use in and about New York Harbor, at Philadelphia and Wilmington, and in Chesapeake Bay accounted for 11,000,000 tons, or 25 per cent of the total.

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Origin and distribution by use and destination of bituminous coal shipped to tidewater in 1918.

[Quantities in net tons.]

Originating field.	Foreign trade.		Domestic trade.											Grand total.
				Cargo.										
	Cargo.	Bunker.	Coastwise bunker.	Virginia, California and South Carolina.	Delaware.	Florida.	Maryland.	New England.		New Jersey.	New York.	Pennsylvania.	Total.	
								Commercial.	Railway fuel.					
Central Pennsylvania	56,512	2,488,547	1,790,677	.....	23,164	3,072	120,221	[a]1,550,877	49,041	618,123	4,145,986	720,003	7,230,547	11,566,283
Greensburg	.....	19,555	30,504	.....	.....	.....	57,428	74,887	310,215	.....	366,595	347	809,472	859,531
Westmoreland [b]	9,344	23,615	65,240	.....	.....	.....	26,575	[c]207,627	[d]439,155	.....	[e]366,205	31,033	1,070,595	1,168,894
Cumberland-Piedmont and Somerset	44,071	574,185	1,249,341	.....	19,106	14,366	330,492	879,614	315,678	126,028	2,377,583	236,089	4,298,956	6,166,553
Pittsburgh [f]	9,214	1,797	7,380	.....	.....	.....	6,630	[g]110,381	[h]67,248	.....	[i]137,919	79,213	401,391	419,782
Fairmont	111,589	16,880	174,476	.....	.....	.....	96,115	1,157,773	1,420,477	82,625	381,663	299,941	3,438,594	3,741,539
Ohio No. 8	.....	.....	102	.....	.....	.....	2,628	10,532	.....	.....	2,261	.....	15,421	15,523
Pocahontas	1,228,731	479,887	1,488,911	[j]90,135	.....	35,622	251,345	[a]3,176,302	118,861	.....	82,120	.....	3,744,385	6,932,914
Tug River	194,933	70,555	73,435	[j]33,046	.....	.....	43,337	506,635	.....	.....	.....	.....	583,018	921,941
Clinch Valley	43,273	6,672	6,945	[j]2,044	.....	.....	4,103	77,492	145,543	.....	.....	.....	229,342	286,132
Thacker	7,718	.....	1,465	[j]49	.....	.....	50,615	32,665	.....	.....	.....	.....	83,329	92,512
Kenova	4,492	.....	793	[j]933	.....	.....	.....	15,530	.....	.....	.....	.....	16,463	21,748
New River	1,853,144	747,114	1,759,818	[j]160,120	.....	43,521	430,920	4,073,017	161,554	.....	57,328	.....	4,926,460	9,286,536
Kanawha	269,269	17,776	78,400	[j]66,137	.....	.....	228,205	324,717	264,199	.....	.....	.....	883,258	1,248,703
Southwestern Virginia	21,786	56,014	11,163	[k]17,395	.....	11,122	47	55,506	105,393	.....	.....	.....	189,463	278,426
Southeastern Kentucky	5,208	4,801	3,125	[l]86	.....	.....	.....	.....	.....	.....	.....	.....	86	13,223
Tennessee	.....	.....	.....	[l]934	.....	190	.....	.....	.....	.....	.....	.....	1,124	1,124
Alabama	127,847	439,473	208,896	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	776,216
Western Kentucky	2,500	5,000	3,000	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	10,500
Illinois	15,400	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	15,400
Texas	.....	15,000	5,000	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	20,000
New Mexico	.....	105,000	25,000	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	130,000
Washington	16,864	306,109	98,095	[m]73,252	.....	.....	.....	.....	.....	.....	.....	.....	73,252	494,320
Utah and southern Wyoming	106	51,688	18,090	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	69,884
	4,022,001	5,420,671	7,099,956	434,131	42,270	107,893	1,648,721	[a]12,253,555	3,397,364	826,776	7,917,660	1,366,686	27,995,056	44,537,684
Imports by tidewater	.....	78,403	.....	[n]38,299	.....	.....	6,735	[o]197,899	198,737	.....	14,506	672	450,848	535,251
									3,590,101					

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a Includes the following tidewater shipments at New England ports:

	Central Pennsylvania.	Pocahontas
Foreign cargo		1,668
Foreign bunker	35,754	122,180
Coastwise bunker	20,000	115,005

b Includes coal originating on Pennsylvania Railroad in Connellsville district.
c Includes 75,000 tons originating in Connellsville district.
d Includes 200,000 tons originating in Connellsville district.
e Includes 100,000 tons originating in Connellsville district.
f Includes coal originating on Baltimore & Ohio and Pittsburgh & Lake Erie Railroads in Connellsville district.
g Includes 34,000 tons originating in Connellsville district.
h Connellsville district figures.
i Includes 41,000 tons originating in Connellsville district.
j Virginia.
k Includes 16,865 tons to South Carolina and 530 tons to Virginia.
l South Carolina.
m California.
n Distributed as follows:

	Tons.		Tons.
Virginia	268	Georgia	757
California	13,000	Oregon	6,063
Texas	448	Washington	12,790
Louisiana	4,973		

o Includes 23,591 tons used for foreign bunker trade.

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Origin and destination of bituminous coal dumped at different ports in 1918.

[Quantities in net tons.]

New York Harbor.

Originating field.	Destination.					
	Cargo.			Bunker.		Total.
	Foreign.	Coastwise.	Local.	Foreign.	Coastwise and other.	
Central Pennsylvania	27,840	1,570,162	4,592,125	2,145,480	1,239,367	9,574,974
Greensburg	.....	385,102	366,437	17,136	30,504	799,179
Westmoreland	.....	417,038	366,205	23,615	62,860	869,718
Cumberland - Piedmont, Somerset, and Meyersdale	9,183	878,688	2,450,604	368,603	667,351	4,374,429
Pittsburgh	3,480	110,057	137,919	1,797	6,783	260,036
Fairmont	14,040	695,844	426,878	16,380	167,019	1,320,661
Ohio No. 8	.....	1,477	2,261	.....	.....	3,738
	54,543	4,058,368	8,342,429	2,573,511	2,173,884	17,202,735

Philadelphia Harbor.

Originating field.	Destination.					
	Cargo.			Bunker.		Total.
	Foreign.	Coastwise.	Inside Capes.	Foreign.	Coastwise and other.	
Central Pennsylvania	46,210	{ [a] 29,756 [b] 17,648 }	880,025	238,535	435,804	1,647,978
Greensburg	.....	.....	347	.....	.....	347
Westmoreland	15,189	[a] 229,744	25,188	.....	2,480	272,601
Pittsburgh	2,117	[a] 45,978	78,353	.....	547	126,995
Cumberland - Piedmont, Somerset, and Meyersdale	18,586	{ [a] 58,569 [b] 38,642 }	248,147	38,145	141,262	543,351
Fairmont	8,468	[a] 183,969	334,256	.....	2,423	529,116
	90,570	604,306	1,566,316	276,680	582,516	3,120,388

[a] New England; total, 548,016 tons. [b] Ports outside of New England; total, 56,290 tons.

Baltimore Harbor.

Originating field.	Destination.					
	Cargo.			Bunker.		Total.
	Foreign.	Coastwise.	Inside Capes.	Foreign.	Coastwise and other.	
Central Pennsylvania	.....	[a] 3,072	120,221	104,532	115,506	343,331
Greensburg	.....	[a] 158	57,428	2,419	.....	60,005
Westmoreland	.....	.....	26,575	.....	.....	26,575
Pittsburgh	4,477	[b] 21,594	6,630	.....	50	32,751
Cumberland - Piedmont, Somerset, and Meyersdale	23,350	{ [b] 258,035 [a] 28,731 }	330,492	167,437	440,728	1,248,773
Fairmont	92,176	[b] 1,698,437	96,115	.....	5,034	1,891,762
Ohio No. 8	.....	[b] 9,055	2,628	.....	102	11,785
	120,003	2,019,082	640,089	274,388	561,420	3,614,982

[a] Ports outside of New England; total, 31,961 tons. [b] New England; total, 1,987,121 tons.

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Origin and destination of bituminous coal dumped at different ports in 1918—Continued.

Hampton Roads.

Originating field.	Destination.					
	Cargo.			Bunker.		Total.
	Foreign.	Coastwise.	Inside Capes.	Foreign.	Coastwise.	
Pocahontas	1,228,731	[a] 3,295,163 [b] 117,742	331,480	470,887	1,488,911	6,932,914
Tug River	194,933	[a] 506,635 [b] 33,046	43,337	70,555	73,435	921,941
Clinch Valley	43,273	[a] 223,035 [b] 2,044	4,163	6,672	6,945	286,132
Thacker	7,718	[a] 32,665 [b] 49	50,615	.....	1,465	92,512
Kenova	4,492	[a] 15,530 [b] 933	.....	.....	793	21,748
New River	1,853,144	[a] 4,284,571 [b] 100,849	591,040	747,114	1,759,818	9,286,536
Kanawha	269,269	[a] 588,916 [b] 66,137	228,205	17,776	78,400	1,248,703
Southwestern Virginia	5,672	[a] 154,347 [b] 530	47	767	.....	161,363
	3,607,232	9,372,192	1,248,887	1,313,771	3,409,767	18,951,849

[a] New England; total, 9,062,062 tons. [b] Ports outside of New England; total, 310,130 tons.

New England ports.

Originating field.	Destination.			
	Cargo (foreign).	Bunker.		Total.
		Foreign.	Coastwise and local.	
Central Pennsylvania	.....	35,754	20,000	55,754
Pocahontas	1,668	122,185	115,000	238,853
Imports	.....	23,591	.....	23,591
	1,668	181,530	135,000	318,198

South Atlantic and Gulf ports.

Originating field.	Destination.					
	Cargo.			Bunker.		Total.
	Foreign.	Coastwise.	Local.	Foreign.	Coastwise.	
Southwestern Virginia	16,114	[a] 6,552 [b] 26,423	1,564	55,247	11,163	117,063
Southeastern Kentucky	5,208	.....	86	4,804	3,125	13,223
Tennessee	.....	[b] 190	934	.....	.....	1,124
Alabama	127,847	.....	.....	439,473	208,896	776,216
Western Kentucky	2,500	.....	.....	5,000	3,000	10,500
Illinois	15,400	.....	.....	.....	.....	15,400
Texas	.....	.....	.....	15,000	5,000	20,000
New Mexico	.....	.....	.....	105,000	25,000	130,000
	167,069	33,165	2,584	624,524	256,184	1,083,526

[a] New England. [b] Ports outside of New England; total, 26,613 tons.

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Origin and destination of bituminous coal dumped at different ports in 1918—Continued.

Pacific coast ports.

Originating field.	Destination.				
	Cargo.		Bunker.		Total.
	Foreign.	Coastwise.	Foreign.	Coastwise.	
Washington	16,864	73,252	306,109	98,095	494,320
Utah and southern Wyoming	106	.....	51,688	18,090	69,884
Imports	.....	.....	78,403	.....	78,403
	16,970	73,252	436,200	116,185	642,607

LAKE COAL TRAFFIC.

All records of Lake coal traffic were broken in 1918 with the loading of more than 28,000,000 net tons at lower Lake Erie ports. The requirements of both Canada and the portion of the United States dependent for its supply of bituminous coal on shipments by way of the Lakes were placed by the Fuel Administration early in the shipping season of 1918 at 28,000,000 tons of cargo coal, compared with 26,828,756 tons in 1917 and 26,830,347 tons in 1913, the previous high record. For the record of the measures that were necessary to forward that quantity of coal and the unusual and exceptional steps taken by the Fuel Administration to maintain a flow of coal from the eastern coal fields to Lake Erie, the reader is referred to the report of the Distribution Division of the Fuel Administration, particularly to the section on Lake coal in Part I and the report on the zone system in Part II.

The Lake coal program in 1917 was a subject of much debate and of several untried expedients. The Committee on Coal Production in June, 1917, brought together the representatives of the railroads and the Lake coal shippers, and as a result a pooling arrangement was effected for the purpose of reducing the detention of loaded coal cars at the lower Lake ports and thereby increasing the volume of traffic. Subsequently the Director of Transportation Priority issued an order making it mandatory for shippers of bituminous coal on all railroads tributary to the Lake Erie ports to give preference to shipments for the Lake trade. Through the operation of these measures the exceptional quantity of over 26,000,000 tons of bituminous coal was dumped at Lake Erie ports in 1917.

The pooling arrangements were made a part of the machinery of the Fuel and Railroad administrations and the boat operators in the season of 1918, but no attempt was made to reinvoke the system of priority of transportation in force in 1917. As explained in the reports of the Distribution Division of the Fuel Administration, the flow of coal to Lake Erie ports in 1918 was maintained by the control of distribution effected by the zone and budget systems. The benefits derived from the "pooling" of coal are made evident in the figures of car detention in the Lake trade. In 1916, with no regulation nor pooling and with only the demurrage rules of the railroads tending to hasten the unloading of cars of coal, the average detention or delay in unloading was 3.50 days. In 1917, with the first attempt

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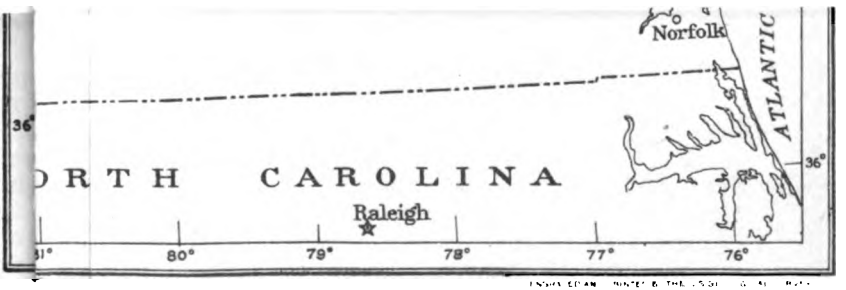

AND THE ALL-RAIL MOVEMENT OF
IANA IN 1918
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at pooling begun in June, after the season was well under way, the average detention was 2.31 days. In 1918, with full control of both coal and the railroads, the average detention was reduced to 1.59 days. The main consideration that prompted the pooling arrangements was the saving in transportation effected by the decrease in car detention. Under normal conditions the shippers of coal do not favor pooling, because the practice eliminates to a large extent the individual "brands" of coal and prevents the vendor from realizing on that most important element in coal merchandising, the delivery of special-quality products. This is indicated by the fact that in 1916 there were 536 classifications under which coal was consigned to the lower Lake ports for transshipment. In 1917, under the first pooling arrangement, the number was reduced to 170, and in 1918 to 160. In 1919, with no public pooling and with conditions similar to those in 1916, except that the handling of Lake coal traffic was under the unified control of the United States Railroad Administration, the number of classifications was 265.

In practice the pooling arrangement operated about as follows: All shipments of coal of a certain grade, such as lump, originating on a railroad in a single field were classified as belonging to one pool, to which a number was assigned. The way bills or other documents that accompanied a car of this coal bore a record of the pool number. To make up a cargo of a given pool number any or all cars of coal of that pool were dumped indiscriminately. Under normal conditions each shipper would have held the cars of his coal at the port until a sufficient number had been accumulated to make a cargo of his special coal and would accordingly have delivered coal of a definite, known quality.

Coal even from the same bed and from near-by mines may vary considerably in quality, often for no other reason than difference in preparation. The inevitable result of pooling is to mix good and poor coals, to the disadvantage of both the shipper of good coal and the purchaser.

It will perhaps assist in the understanding of the following statistics of Lake coal traffic, to describe briefly the reasons why this traffic is maintained and why it is so large; it has not been less than 20,000,000 tons a year in the last nine years.

What is commonly known as the Northwest—Wisconsin, Minnesota, North Dakota, South Dakota, and the northern edge of Iowa, in the United States, and a portion of Canada bordering on the Great Lakes—a territory that requires coal for railroads, homes, iron and copper mines, paper mills, and growing manufacturing industries, has no local source of fuel supply. As shown on the accompanying map, the nearest coal fields to this territory are in the Appalachian region on the east and southeast—the coal fields extending from Ohio and western Pennsylvania southward to Tennessee—and those in Illinois, Indiana, and western Kentucky and in Iowa and the Southwestern States on the south. The nearest Canadian coal fields are in the Maritime Provinces on the east and in Alberta and British Columbia on the west. The Canadian market on and adjacent to the upper Great Lakes, in which the railroads are the largest consumers, is almost entirely dependent for its supply of coal, both anthracite and bituminous, on that shipped from the United States across the Lakes or by rail through the gateways at Buffalo and

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Detroit. The American Northwest obtains coal by rail from the fields in Illinois, Indiana, and western Kentucky, which may be referred to as the Eastern Interior field, and by Lake from the fields in the East.

There are several reasons that explain the relatively greater increase in the use of eastern coal transported by way of the Lakes, compared with that of Eastern Interior coal, in this American Northwest market. The rail-Lake-rail movement is an economical use of transportation facilities. Each year the tonnage of iron ore produced in the Northwest for shipment to iron furnaces in the East is greater than that of coal used in the Northwest. In addition large quantities of grain are gathered in from the agricultural States about the head of the Lakes for transshipment east. The great volume of traffic on the Lakes goes east, and in normal times the operators of Lake vessels have found it profitable to take return cargoes of coal on the westbound trips at very low rates.

At the present time (1919) the approximate number of bulk freight vessels on the Great Lakes is 400, and the number used in the coal-carrying trade is about 200. It requires about 80 hours (3.3 days) for a coal-laden vessel to go from the lower Lake ports to Duluth. The coal capacity of the largest vessel in the Lake trade is 16,000 net tons. The largest cargo loaded of which there is record was 15,533 net tons on the *D. G. Kerr*, on September 5, 1919. The *Schoonmaker* has a somewhat greater cubical capacity than the *Kerr* and could load 16,000 tons of the same kind of coal, and the draft of the vessel would permit carrying that tonnage on the Lakes.[1]

Furthermore, the eastern coal is superior in quality to that produced in the Eastern Interior fields and has commanded a higher price because of its better quality. Not the least important of the reasons for the growth of the Lake trade is the desirability of the region it serves as a summer market for producers in the eastern fields, particularly western Pennsylvania, Ohio, and southern West Virginia. Under normal conditions the demand for coal is greatest in the winter and least in the summer. The Lakes are closed to navigation because of weather conditions from some time in December until the following April, and all the coal that is to be shipped by that route must be moved between April 1 and the middle of December. In that period the markets for coal reached by all rail from the eastern fields are least active, and the opportunity to maintain the operation of the mines during the summer by shipping to the Lakes is welcomed by the producer. So well recognized is this fact that the larger producers in the eastern fields tributary to the Lakes maintain organizations at the head of the Lakes and have their own docks and other equipment there, and during periods when the market near at hand is dull these producers ship coal to themselves at the head of the Lakes, where, if there is no demand during the summer, the coal is stored on the docks awaiting the winter market. The producer is thus enabled to operate his mines more or less continuously.

[1] The writer is indebted for this and other information on Lake coal traffic to Mr. Herman M. Griggs, manager, Ore and Coal Exchange, Cleveland, Ohio.

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According to Mr. W. H. Groverman,[1] secretary of the Northwestern Coal Dock Operators' Association, the docks at Duluth-Superior have a combined capacity of 9,045,000 tons of bituminous coal and 1,377,000 tons of anthracite. On these docks anthracite is stored under cover. The largest single dock has a capacity of 800,000 tons of bituminous coal and 200,000 tons of anthracite, a total of 1,000,000 net tons.

The statistics of Lake coal traffic in 1918 are given in the following tables. The record of shipments to the Lake ports from Erie, Pa., on the east, to Toledo, Ohio, on the west, shows that the Pittsburgh (Pa.) field is the largest single source of lake coal, and that Toledo is the port that handles the greatest quantity. Beginning with 862,158 tons in April, the shipments, by months, increased to 5,167,646 tons in October, by far the highest ever recorded in a single month.

Coal for bunkering the Lake steamers, known to the trade as "vessel fuel," amounted to 1,615,623 net tons in 1918. Its source, by fields, is given in the following table:

Lake fuel coal, by districts, 1918.

	Net tons.
Pittsburgh	884,216
Central Pennsylvania	231
Northern Pennsylvania	5,714
Fairmont	13,665
Kanawha and Kenova-Thacker	122,115
Northern Ohio	416,080
Southern Ohio	154,611
Northeastern Kentucky	18,991
	1,615,623

Car ferries are used on Lake Erie, Lake Michigan, and Lake Ontario for carrying coal without transshipment on vessels. From the port of Charlotte, N. Y., on Lake Ontario, coal is shipped to Canada and to American points down the lake, both in cargo vessels and in car ferries. This traffic is not included in these statistics.

The car ferries on Lake Erie are used for transporting coal to Canada, but the coal so shipped is not included in these statistics because it is not moved as cargo in vessels.

The car ferries across Lake Michigan carried 257,685 net tons in 1918, originating in the districts indicated in the following table:

Bituminous coal shipments across Lake Michigan by car ferry, 1918, in net tons.

Producing district.	Commercial fuel.	Railroad fuel.	Total.
Pittsburgh	1,728	6,671	8,399
Central Pennsylvania	1,306	123	1,429
Northern Ohio	20,697	16,804	37,501
Southern Ohio	10,171	3,076	13,247
Fairmont	4,736	.....	4,736
Kanawha	87,884	.....	87,884
Kenova-Thacker	22,539	.....	22,539
Cumberland-Piedmont	1,518	.....	1,518
New River	25,786	246	26,032
Pocahontas	5,538	.....	5,538
Kentucky	48,808	.....	48,808
Virginia	54	.....	54
	230,765	26,920	257,685

[1] Personal communication.

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Shipments of bituminous coal to lower Lake ports in 1918, by months, in net tons.

Producing district.	January to April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.
Pittsburgh	395,714	915,363	896,174	1,077,015	1,282,797	1,133,736	1,665,906	614,603	10,886	[a] 7,992,194
Central Pennsylvania	74	11,928								12,002
Northern Pennsylvania		3,356	9,225	20,102	22,548	20,375	52,450	17,449	32	145,537
Northern Ohio	261,789	689,257	725,720	913,595	1,059,340	1,020,046	1,071,969	575,146	3,651	6,320,513
Southern Ohio	56,015	334,752	376,341	421,343	539,711	562,750	646,504	278,066	739	3,216,221
Fairmont	27,475	82,716	126,104	186,776	242,040	238,124	232,926	180,938	185	1,317,284
Kanawha, Chesapeake & Ohio Ry. east of St. Albans			184,131	272,541	266,504	209,607	225,277	161,273	394	1,319,787
Kanawha, Chesapeake & Ohio Ry. west of St. Albans	35,433	396,432	381,757	362,510	398,830	417,715	422,782	272,158	858	2,688,475
	35,433	396,432	565,888	635,051	665,334	627,382	648,059	433,431	1,252	4,008,262
Kanawha, Kanawha & Michigan Ry.	36,943	146,777	158,594	183,112	217,589	175,287	166,757	106,756	686	1,192,501
Thacker-Kenova	1,383	101,017	92,502	78,099	134,655	114,423	60,100	43,442		625,621
New River		22,964	38,211	39,720	83,854	67,199	69,906	39,342	254	361,450
Pocahontas	43,433	185,896	240,099	175,251	241,713	301,191	300,220	151,915	10,547	1,650,265
Northeastern Kentucky	3,899	64,216	107,285	103,178	121,005	106,332	107,337	35,804	106	649,162
Southeastern Kentucky		18,412	38,140	80,288	162,430	180,116	145,512	40,442	52	[b] 665,392
Tennessee					97					97
	862,158	2,973,086	3,374,283	3,913,530	4,773,113	4,546,961	5,167,646	2,517,334	28,390	28,156,501

[a] Includes 458,360 tons originating in the Connellsville district, and 453,672 tons originating in the Greensburg-Westmoreland field.
[b] Includes 155,647 tons of coal from northeastern Kentucky and 270,902 tons from Hazard, Ky.

Shipments of bituminous coal to lower Lake ports in 1918, by districts, in net tons.

Producing district.	Toledo.	Sandusky.	Huron.	Lorain.	Cleveland.	Fairport.	Ashtabula.	Conneaut.	Erie.	Total.
Pittsburgh			270,687	48,723	1,510,087	217,579	2,927,298	2,115,237	902,583	[a] 7,992,194
Central Pennsylvania									12,002	12,002
Northern Pennsylvania								99,820	45,717	145,537
Northern Ohio		77,917	1,795,346	2,199,030	1,702,171		338,673		207,376	6,320,513
Southern Ohio	3,214,457	1,764								3,216,221
Fairmont	577			1,092,167			170,302			1,317,284
Kanawha, Chesapeake & Ohio Ry. east of St. Albans	1,308,603	11,184								1,319,787
Kanawha, Chesapeake & Ohio Ry. west of St. Albans	2,666,108	22,367								2,688,475
	3,974,711	33,551								4,008,262

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Kanawha, Kanawha & Michigan Ry.	1,192,501									1,192,501
Thacker-Kenova	24	625,597				54,238				625,621
New River	357,144	4,306								361,450
Pocahontas	34,142	1,616,123								1,650,265
Northeastern Kentucky	649,026	136								649,162
Southeastern Kentucky	665,392									[b] 665,392
Tennessee	97									97
	10,088,071	2,359,394	2,066,033	3,339,920	3,212,258	271,817	3,436,273	2,215,057	1,167,678	28,156,501

[a] Includes 458,360 tons originating in the Connellsville district and 453,672 tons originating in the Greensburg-Westmoreland district.
[b] Includes 155,647 tons originating in northeastern Kentucky and 270,902 tons in the Hazard field, Kentucky.

Shipments of bituminous coal to lower Lake ports, 1910–1918, in net tons.

Producing district.	1910	1911	1912	1913	1914	1915	1916	1917	1918
Pittsburgh	10,197,127	10,071,930	9,893,870	12,261,334	10,216,126	9,350,166	8,672,829	6,659,447	[a] 7,992,194
Pennsylvania (outside)	245,116	155,877	158,719	301,179	423,609	269,535	94,709	889,369	(b)
Central Pennsylvania									[c] 12,002
Northern Pennsylvania									[c] 145,537
Northern Ohio	2,303,278	2,739,069	3,094,388	4,248,309	512,123	2,168,481	4,474,067	4,913,771	6,320,513
Southern Ohio	1,464,684	1,370,925	1,223,249	1,397,718	734,456	315,846	827,906	2,907,625	3,216,221
Fairmont	1,611,005	1,784,279	1,686,729	2,161,523	2,214,672	2,030,408	1,617,945	1,029,201	1,317,284
Kanawha, Chesapeake & Ohio Ry. east of St. Albans									1,319,787
Kanawha, Chesapeake & Ohio Ry. west of St. Albans									2,688,475
	1,343,148	1,799,956	1,160,736	1,570,477	2,202,076	2,181,668	2,930,765	3,674,768	4,008,262
Kanawha, Kanawha & Michigan Ry	1,272,169	1,307,576	1,053,320	1,385,844	1,263,866	1,321,172	1,272,618	1,421,561	1,192,501
Thacker-Kenova	320,317	380,619	366,140	587,648	627,167	628,348	884,871	977,854	625,621
Cumberland-Piedmont	102,219	43,545	34,750	32,741	35,961	26,229	11,250	6,307	
New River	410,031	639,217	988,985	488,338	414,474	338,671	505,396	578,314	361,450
Pocahontas	987,124	1,324,192	1,622,467	1,998,116	1,880,260	2,175,676	2,480,822	2,575,956	1,650,265
Northeastern Kentucky		6,075	20,487	386,396	842,466	633,566	745,137	651,397	649,162
Southeastern Kentucky	11,031	3,743	6,164	10,724	16,361	67,608	174,621	537,369	665,392
Virginia								990	
Tennessee								4,827	97
	20,267,249	21,627,003	21,310,004	26,830,347	21,383,617	21,507,374	24,692,936	26,828,756	28,156,501

[a] Includes quantity (620,746 tons in 1918) shown as Pennsylvania (outside) from 1910 to 1917.
[b] Included in Pittsburgh district in 1918.
[c] Included in Pennsylvania (outside), 1910 to 1917.

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BITUMINOUS COAL AND LIGNITE SHIPPED BY RAILROADS AND RIVERS.

According to the reports furnished to the Geological Survey by the coal operators, bituminous coal and lignite shipped by railroads in 1918 amounted to 503,088,528 net tons, compared with 469,850,975 tons in 1917. The shipments, which are summarized by railroads in the accompanying table, include all coal loaded on cars at the mines. A small part of the coal shipped is carried only a short distance, perhaps only switched from the tipple to coke ovens or to some adjacent industrial plant, but the greater part is moved a considerable distance from the mines. As these statistics include fuel coal taken by railroads that serve the coal mines, not all the shipments furnished revenue to the railroads, coal for "company use" being nonrevenue freight. The statistics of coal traffic published by a railroad company usually show only revenue freight and include coal received from connecting lines as well as that originating at mines on the line. For that reason the figures given in the following table will be at variance with those that may be compiled by the railroads.

The quantities of bituminous coal and lignite shipped on each road are given in so far as they can be published without disclosing the output of individual mines. The name of every railroad on which coal was reported to have originated is given, and for most of the roads the quantity from each State. Roads on which the mines are operated by less than three companies are grouped in such a manner as to avoid disclosing the operations of mines or companies.

Shipments originating on rivers are given at the end of the table.

Bituminous coal shipped in the United States in 1918, by railroads and waterways, in net tons.

Route.	State.	Quantity.	
		By States.	Total.
Railroad.			
Alabama Central	Alabama	37,959	37,959
Altoona Northern	Pennsylvania	82,656	82,656
Arkansas Central	Arkansas	39,590	39,590
Arkansas Western	do	20,200	20,200
Ashland Coal & Iron	Kentucky	183,152	183,152
Atchison, Topeka & Santa Fe	Colorado	992,028	5,569,427
	Illinois	278,306	
	Kansas	1,848,310	
	Missouri	626,360	
	New Mexico	1,668,202	
	Oklahoma	156,221	
Atlanta, Birmingham & Atlantic	Alabama	185,866	185,866
Baltimore & Ohio	Illinois	2,066,713	36,918,809
	Indiana	318,647	
	Kentucky	357,103	
	Maryland	76,971	
	Ohio	10,272,801	
	Pennsylvania	10,245,827	
	West Virginia	13,560,738	
Bessemer & Lake Erie	Pennsylvania	4,613,929	4,613,929
Big Sandy & Cumberland	Kentucky	11,940	11,940
Big Sandy & Kentucky River	do	14,100	14,100
Birmingham Southern	Alabama	2,438,657	2,438,657
Buffalo & Susquehanna	Pennsylvania	1,588,039	1,588,039
Buffalo, Rochester & Pittsburgh	do	10,966,765	10,966,765
Cambria & Indiana	do	1,925,112	1,925,112
Campbells Creek	West Virginia	377,365	377,365
Carolina, Clinchfield & Ohio	Kentucky	52,347	1,917,766
	Virginia	1,865,419	
Caseyville	Illinois	10,983	10,983
Central Indiana	Indiana	120,839	120,839

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Bituminous coal shipped in the United States in 1918, by railroads and waterways, in net tons—Continued.

Route.	State.	Quantity. By States.	Quantity. Total.
Railroad—Continued.			
Central of Georgia	Alabama	686,442	708,167
	Georgia	21,725	
Chesapeake & Ohio	Kentucky	2,555,950	27,934,830
	West Virginia	25,378,880	
Chicago & Alton	Illinois	3,364,109	3,654,926
	Missouri	290,817	
Chicago & Eastern Illinois	Illinois	6,772,865	15,385,130
	Indiana	8,612,265	
Chicago & Illinois Midland	Illinois	1,851,531	1,851,531
Chicago & North Western	....do	5,022,947	7,332,361
	Iowa	2,089,576	
	Wyoming	219,838	
	Colorado	431,089	
	Illinois	13,534,415	
Chicago, Burlington & Quincy	Iowa	924,863	18,718,681
	Missouri	1,141,813	
	Wyoming	2,686,501	
Chicago Great Western	Iowa	194,392	194,392
Chicago, Indianapolis & Louisville	Indiana	2,179,450	2,179,450
	Illinois	1,074,076	
	Iowa	1,354,172	
	Montana	1,152,976	
Chicago, Milwaukee & St. Paul	North Dakota	12,106	3,661,816
	South Dakota	640	
	Washington	67,846	
Chicago, Peoria & St. Louis	Illinois	1,000,992	1,000,992
	Arkansas	237,221	
	Colorado	1,618	
	Illinois	220,342	
Chicago, Rock Island & Pacific	Iowa	1,862,898	3,669,577
	Missouri	143,358	
	Oklahoma	1,164,815	
	Texas	39,325	
Chicago, Terre Haute & Southeastern	Indiana	5,633,318	5,633,318
Cincinnati, Indianapolis & Western	Illinois	268,827	286,927
	Indiana	18,100	
Cleveland, Cincinnati, Chicago & St. Louis	Illinois	8,320,605	9,133,454
	Indiana	812,849	
Coal & Coke	West Virginia	1,765,887	1,765,887
Colorado & Southeastern	Colorado	551,879	551,879
Colorado & Southern	....do	3,427,578	3,427,578
Colorado & Wyoming	....do	150,148	150,148
Colorado Midland	....do	92,672	92,672
Colorado, Wyoming & Eastern	....do	83,432	83,432
Crystal River	....do	7,693	7,693
Cumberland	Kentucky	146,198	146,198
Cumberland & Manchester	....do	42,805	42,805
	Maryland	2,658,826	
Cumberland & Pennsylvania	Pennsylvania	84,230	2,764,306
	West Virginia	21,250	
Dayton, Toledo & Chicago	Ohio	3,758	3,758
Denver & Intermountain	Colorado	112,782	112,782
	....do	3,186,324	
Denver & Rio Grande	New Mexico	11,284	6,055,898
	Utah	2,858,290	
Denver & Salt Lake	Colorado	893,210	893,210
Detroit, Toledo & Ironton	Ohio	429,868	429,868
East Broad Top	Pennsylvania	619,558	619,558
Eastern Kentucky	Kentucky	48,367	48,367
Eastern Railway & Lumber Co	Washington	30,186	30,186
East St. Louis & Suburban	Illinois	904,299	904,299
Elgin, Joliet & Eastern	....do	298,392	298,392
El Paso & Southwestern	New Mexico	857,202	857,202
	Ohio	88,176	
Erie	Pennsylvania	1,563,860	1,652,036
Evansville & Indianapolis	Indiana	732,427	732,427
Evansville Railways (Electric)	....do	102,647	102,647
Evansville, Suburban & Newburgh	....do	219,986	219,986
Fort Dodge, Des Moines & Southern	Iowa	166,696	166,696
Fort Smith & Western	Oklahoma	263,294	263,294
Fort Smith, Subiaco & Eastern	Arkansas	8,011	8,011
Grand Trunk	Michigan	19,650	19,650
	Montana	1,516,170	
Great Northern	North Dakota	86,950	1,609,017
	Washington	5,897	
Hocking-Sunday Creek Traction	Ohio	4,000	4,000
Hocking Valley	....do	6,258,936	6,258,936
Huntingdon & Broad Top Mountain	Pennsylvania	1,172,139	1,172,139

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Bituminous coal shipped in the United States in 1918, by railroads and waterways, in net tons—Continued.

Route.	State.	Quantity. By States.	Quantity. Total.
Railroad—Continued.			
Illinois Central	Illinois	15,753,091	20,738,556
	Indiana	436,432	
	Kentucky	4,549,033	
Illinois Southern	Illinois	311,481	311,481
Illinois Traction	do	631,664	631,664
Indiana County Street Railway	Pennsylvania	11,130	11,130
Indian Creek Valley	do	159,878	159,878
International & Great Northern	Texas	390,180	390,180
Interstate	Virginia	1,511,063	1,511,063
Interurban	Iowa	341,181	341,181
Iowa Southern Utilities	do	36,039	36,039
Johnstown & Stony Creek	Pennsylvania	263,091	263,091
Joplin & Pittsburg	Kansas	142,838	142,838
Kanawha & Michigan	Ohio	2,146,411	4,927,864
	West Virginia	2,781,453	
Kanawha, Glen Jean & Eastern	do	509,433	509,433
Kansas City, Clinton & Springfield	Missouri	8,077	8,077
Kansas City Northwestern	Kansas	28,420	32,325
	Missouri	3,905	
Kansas City Southern	Kansas	676,925	1,045,270
	Missouri	274,473	
	Oklahoma	93,872	
Kentucky & Tennessee	Kentucky	568,660	568,660
Kentucky Midland	do	123,574	123,574
Lake Erie & Western	Illinois	675	675
Lake Erie, Franklin & Clarion	Pennsylvania	417,143	417,143
Ligonier Valley	do	954,514	954,514
Litchfield & Madison	Illinois	1,184,465	1,184,465
Louisville & Nashville	Alabama	3,801,002	21,429,341
	Illinois	1,565,804	
	Kentucky	14,957,978	
	Tennessee	948,309	
	Virginia	156,248	
Louisville, Henderson & St. Louis	Kentucky	118,729	118,729
McKeesport Connecting	Pennsylvania	16,910	16,910
Marion & Eastern	Illinois	204,000	204,000
Mary Lee	Alabama	144,637	144,637
Michigan Central	Michigan	729,360	729,360
Midland Valley	Arkansas	333,696	415,596
	Oklahoma	81,900	
Minneapolis & St. Louis	Illinois	919,330	1,289,771
	Iowa	370,441	
Minneapolis, St. Paul & Sault Ste. Marie	Montana	4,635	281,974
	North Dakota	277,339	
Missouri, Kansas & Texas	Kansas	485,975	2,733,638
	Missouri	132,491	
	Oklahoma	1,486,933	
	Texas	628,237	
Missouri, Oklahoma & Gulf	Oklahoma	682,844	682,844
Missouri Pacific	Arkansas	876,031	7,412,631
	Illinois	3,751,876	
	Kansas	1,419,762	
	Missouri	1,364,962	
Mobile & Ohio	Alabama	529,584	1,868,025
	Illinois	1,338,441	
Monongahela	Pennsylvania	3,824,937	5,332,461
	West Virginia	1,507,524	
Montana, Wyoming & Southern	Montana	616,168	616,168
Montour	Pennsylvania	3,902,254	3,902,254
Morehead & North Fork	Kentucky	24,445	24,445
Morgan & Fentress	Tennessee	10,812	10,812
Morgantown & Kingwood	West Virginia	767,122	767,122
Morgantown & Wheeling	do	255,672	255,672
Nashville, Chattanooga & St. Louis	Alabama	17,565	1,177,894
	Tennessee	1,160,329	
New Mexico Central	New Mexico	10,940	10,940
New Mexico Midland	do	84,008	84,008
New York Central	Michigan	10,064	11,646,759
	Ohio	2,731,006	
	Pennsylvania	8,904,489	
Norfolk & Western	Kentucky	3,164,649	28,247,744
	Ohio	13,053	
	Virginia	2,928,328	
	West Virginia	22,141,214	
Norfolk Southern	North Carolina	466	466
Northern Pacific	Montana	887,945	3,558,403
	North Dakota	149,651	
	Washington	2,520,807	

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Bituminous coal shipped in the United States in 1918, by railroads and waterways, in net tons—Continued.

Route.	State.	Quantity. By States.	Quantity. Total.
Railroad—Continued.			
Norton & Northern	Virginia	85,861	85,861
Ohio & Kentucky	Kentucky	78,883	78,883
Oneida & Western	Tennessee	23,808	23,808
Oregon Short Line	Wyoming	1,877,162	1,877,162
Oregon-Washington Railroad & Navigation Co	Washington	264,532	264,532
Owensboro City	Kentucky	12,248	12,248
Pacific Coast	Washington	655,111	655,111
Pennsylvania East	Pennsylvania	52,330,831	52,330,831
Pennsylvania West	Illinois	1,707,212	31,201,775
	Indiana	8,075,978	
	Ohio	10,697,097	
	Pennsylvania	9,411,904	
	West Virginia	1,309,584	
Peoria & Pekin Union	Illinois	507,627	507,627
Peoria Railway Terminal	do	80,094	80,094
Pere Marquette	Michigan	520,984	520,984
Pittsburgh & Lake Erie	Pennsylvania	6,526,931	6,526,931
Pittsburg & Shawmut	do	2,402,553	2,402,553
Pittsburgh & Susquehanna	do	237,074	237,074
Pittsburgh & West Virginia	Ohio	1,382,053	5,146,487
	Pennsylvania	3,520,538	
	West Virginia	243,896	
Pittsburgh, Chartiers & Youghiogheny	Pennsylvania	1,125,076	1,125,076
Pittsburg County Electric	Oklahoma	31,095	31,095
Pittsburgh, Lisbon & Western	Ohio	37,190	77,708
	Pennsylvania	40,518	
Pittsburg, Shawmut & Northern	do	487,769	487,769
Puget Sound Electric	Washington	115,451	115,451
Quincy, Omaha & Kansas City	Missouri	146,993	146,993
Rio Grande & Eagle Pass	Texas	92,904	92,904
Rock Island Southern	Illinois	246,863	246,863
St. Louis & Belleville Electric	Illinois	513,293	513,293
St. Louis & Hannibal	Missouri	10,366	10,366
St. Louis & O'Fallon	Illinois	1,101,168	1,101,168
St. Louis-San Francisco	Alabama	2,602,958	6,717,092
	Arkansas	507,243	
	Kansas	2,559,674	
	Missouri	350,261	
	Oklahoma	606,956	
St. Louis-Southwestern	Texas	110,282	110,282
St. Louis, Troy & Eastern	Illinois	1,341,345	1,341,345
Sandy Valley & Elkhorn	Kentucky	1,326,077	1,326,077
Santa Fe, Raton & Eastern	New Mexico	204,565	204,565
Seaboard Air Line	Alabama	95,025	95,025
Southern	Alabama	4,748,566	13,396,818
	Illinois	1,627,309	
	Indiana	1,671,676	
	Kentucky	743,266	
	Tennessee	2,964,918	
	Virginia	1,641,083	
Southern Illinois Railway & Power Co	Illinois	2,100	2,100
Southern Pacific	California	5,800	134,666
	Oregon	4,112	
	Texas	124,754	
Southern Traction	Illinois	32,770	32,770
Springfield Terminal	do	534,030	534,030
Steubenville, East Liverpool & Beaver Valley Traction	Pennsylvania	36,736	36,736
Susquehanna & New York	do	2,249	2,249
Tennessee	Tennessee	83,665	83,665
Tennessee Central	do	712,252	712,252
Terre Haute, Indianapolis & Eastern	Indiana	3,949	3,949
Texas & Pacific	Texas	763,023	763,023
Texas Short Line	do	41,661	41,661
Thomas & Sayreton	Alabama	559,666	559,666
Toledo & Ohio Central	Ohio	3,857,715	3,857,715
Toledo & Western	Indiana	10,246	10,246
Toledo, Peoria & Western	Illinois	303,824	303,824
Toledo, St. Louis & Western	do	749,061	749,061
Trinity & Brazos Valley	Texas	13,900	13,900
Uintah	Colorado	13,284	13,284
Union	Pennsylvania	45,463	45,463
Union Pacific	Colorado	637,074	5,049,936
	Kansas	26,454	
	Missouri	55,979	
	Utah	58,928	
	Wyoming	4,271,501	

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Bituminous coal shipped in the United States in 1918, by railroads and waterways, in net tons—Continued.

Route.	State.	Quantity.	
		By States.	Total.
Railroad—Continued.			
Utah	Utah	1,321,500	1,321,500
Virginian	West Virginia	6,480,202	6,480,202
Wabash	Illinois	3,702,676	4,331,184
	Iowa	58,772	
	Missouri	569,736	
Wabash, Chester & Western	Illinois	130,987	130,987
Washington Run	Pennsylvania	101,369	101,369
Western Allegheny	do	333,771	333,771
Western Maryland	Maryland	1,607,496	5,706,363
	Pennsylvania	599,021	
	West Virginia	3,499,846	
West Virginia Midland	do	6,258	6,258
West Virginia Northern	do	347,557	347,557
Wheeling & Lake Erie	Ohio	4,630,018	4,630,018
Woodstock & Blocton	Alabama	175,739	175,739
Woodward Iron Co	do	5,064	5,064
Wyoming	Wyoming	250	250
Youngstown & Ohio River	Ohio	261,499	261,499
Miscellaneous	Alaska	63,051	63,051
Total railroad shipments		493,072,816	493,072,816
Waterway.			
Green River	Kentucky	39,031	39,031
Illinois River	Illinois	18,276	18,276
Kanawha River	West Virginia	608,527	608,527
Kentucky River	Kentucky	30,000	30,000
Monogahela River	Pennsylvania	8,974,716	8,980,521
	West Virginia	5,805	
Ohio River	Indiana	12,842	301,380
	Kentucky	202,406	
	Ohio	74,429	
	West Virginia	11,703	
Tennessee River	Tennessee	500	500
Warrior River	Alabama	33,261	33,261
Miscellaneous	Alaska	4,216	4,216
Total waterway shipments		10,015,712	10,015,712
Grand total		503,088,528	503,088,528

DISTRIBUTION OF COAL, BY PRODUCING DISTRICTS.

CENTRAL PENNSYLVANIA.

The distribution of coal from central Pennsylvania in 1918 was influenced by the Fuel Administration program, which required increased shipments from this field to New England. During the year New England received by rail from central Pennsylvania nearly 1,000,000 tons of coal more than in 1917. The quantity used within the State of Pennsylvania declined in part because of the decrease in the use of coke in beehive ovens in the central Pennsylvania field. The shipments to tidewater increased, and the shipments by rail and Lake Ontario to Canada increased from 4,140,000 to 4,344,000 tons. The quantity of railroad fuel shipped by all-rail routes was about the same in both years.

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Distribution of coal produced in central Pennsylvania [a] in 1917–18.

	Quantity (net tons).		Percentage of total.	
	1917	1918	1917	1918
Used in Pennsylvania:				
Sold to local trade, not shipped	2,239,021	1,744,212		
Used at mines for steam and heat	1,160,397	1,168,335		
Made into coke at mines	2,923,034	2,680,891		
Shipped to Pennsylvania points	6,582,783	6,688,693		
	12,905,235	12,282,131	21.9	19.9
Shipped to other States:				
California	.....	5,525		
Delaware	190,000	316,355		
District of Columbia	30,000	20,000		
Illinois	52,000	38,088		
Indiana	25,000	44,708		
Maryland	104,000	21,798		
Michigan	25,000	23,877		
Missouri	.....	3,209		
New England	5,847,364	[b] 6,801,338		
New Jersey	1,951,000	2,051,765		
New York	5,950,000	5,701,657		
Ohio	175,000	105,750		
Wisconsin	.....	1,306		
Lake vessel fuel	.....	231		
Miscellaneous	75,000	97,527		
	14,424,364	15,233,134	24.4	24.7
Delivered to railroads by all-rail routes [c]	18,023,766	18,190,635	30.5	29.6
Exported by rail	3,070,000	[d] 4,344,524	5.2	7.1
Shipped to tidewater	9,550,146	11,566,283	16.2	18.7
Shipped to Lake Ontario for cargo	1,070,581	(d)	1.8	.....
Shipped to Lake Erie for cargo	.....	12,002	.....	.....
	59,044,092	61,628,709	100.0	100.0

[a] Includes Bedford, Blair, Cambria, Cameron, Center, Clinton, Elk, Huntingdon, Indiana, (except northwest corner), Jefferson, and McKean counties, Pa.
[b] Includes 229,351 tons of railroad fuel by way of Lake Ontario.
[c] Does not include railroad fuel shipped by tidewater and by Lake Ontario.
[d] Exports to Canada by way of Lake Ontario in 1918 included in rail exports.

NORTHERN PENNSYLVANIA.

The coal from the district here described as northern Pennsylvania is shipped largely to consumers in Pennsylvania and New York and used as railroad fuel. Next in importance as consumers of coal from this district are Canada, New England, New Jersey, and Ohio.

Distribution of coal produced in northern Pennsylvania [a] in 1917–18.

	Quantity (net tons).		Percentage of total.	
	1917	1918	1917	1918
Used in Pennsylvania:				
Sold to local trade, not shipped	367,192	357,406		
Used at mines for steam and heat	200,551	151,196		
Made into coke at mines	.....	.....		
Shipped to Pennsylvania points	1,878,029	2,042,460		
	2,445,772	2,551,062	33.1	31.7
Shipped to other States by rail:				
Delaware	.....	586		
Maryland	.....	586		
Michigan	.....	5,738		
New England	350,000	316,350		
New Jersey	283,000	395,520		
New York	1,647,000	1,498,200		
Ohio	281,000	325,748		
West Virginia	.....	7,215		
Lake vessel fuel	.....	5,714		
	2,561,000	2,555,657	34.7	31.8
Delivered to railroads by all-rail routes	[b] 1,627,090	2,087,382	22.1	25.9
Exported by rail	578,000	711,745	7.8	8.8
Shipped to tidewater	25,000	.....	0.3	.....
Shipped to Great Lakes for cargo	144,466	145,537	2.0	1.8
	7,381,328	8,051,383	100.0	100.0

[a] Includes the western part of Armstrong; Beaver, Butler, western part of Clarion, northwest corner of Indiana; Lawrence, and Mercer counties, Pa.
[b] Does not include 15,000 tons of railroad fuel shipped by Lake.

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WESTMORELAND, GREENSBURG, LATROBE, AND LIGONIER DISTRICTS, PA.

The coal from the Westmoreland, Greenburg, Latrobe, and Ligonier districts is largely (34.8 per cent) taken by the railroads for fuel, the Greensburg and Ligonier districts being predominantly sources of locomotive fuel and the Westmoreland district the source of high-grade gas coal for passenger-engine service on the Pennsylvania Railroad. Little of the coal from these districts is used for other than railroad fuel and industrial purposes, including by-product coke manufacture and steel mills. The Westmoreland coal, that from the Irwin basin, is noted for its high quality for making gas and is used, largely in New England, for this purpose in establishments that furnish gas to municipalities. In the Latrobe district particularly this coal is coked in beehive ovens. Including the coal coked in beehive ovens, about 40.8 per cent of the product of these districts was used in Pennsylvania. The zoning system had little effect on the distribution of this coal in 1918. The efforts of the Fuel Administration in these districts were directed more largely toward obtaining a better utilization of the higher-grade coals, especially that from the Westmoreland district, the production of which was not increased as much as in the other parts of the field. The increase in total production of about 800,000 tons was more than offset by the increase in railroad fuel, and as a consequence decreased shipments were sent to consumers in Pennsylvania, New England, Ohio, and New Jersey, but larger shipments went to New York, and a slightly greater quantity to tidewater.

Distribution of coal produced in Westmoreland, Greensburg, Latrobe, and Ligonier districts, Pa., in 1917–18.

	Quantity (net tons).		Percentage of total.	
	1917	1918	1917	1918
Used in Pennsylvania:				
Sold to local trade, not shipped	288,057	354,104		
Used at mines for steam and heat	323,844	379,226		
Made into coke at mines	3,742,461	3,471,244		
Shipped to Pennsylvania points	3,471,379	3,025,700		
	7,825,741	7,230,274	46.4	40.8
Shipped to other States:				
Delaware	75,000	61,800		
Maryland	25,000	35,295		
Michigan	.....	10,465		
New England	543,000	290,793		
New Jersey	505,000	479,150		
New York	353,000	442,750		
Ohio	750,000	681,622		
	2,251,000	2,001,875	13.3	11.3
Delivered to railroads by all-rail routes	4,835,493	6,142,348	28.6	34.8
Exported by rail	350,000	219,876	2.1	1.2
Shipped to tidewater	1,616,985	1,653,425	9.6	9.3
Shipped to Great Lakes for cargo	.....	453,672	.....	2.6
	16,879,219	17,701,470	100.0	100.0

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FAIRMONT DISTRICT, W. VA.

Increased shipments eastward and decreased shipments westward characterized the distribution of coal from the Fairmont district in 1918, compared with 1917. From April 1 through the year the Fuel Administration permitted only such portion of the output from this district to move west (except to the Lakes for cargo) as could not be handled by the railroads for eastern markets. Shipments to Illinois, Indiana, Michigan, and Ohio were materially reduced. The increase in total production of nearly 2,600,000 tons was largely taken by the railroads and shipped to tidewater or to the Lakes for cargo. Eastern Pennsylvania is the best all-rail market for this district, next to which come New Jersey and Ohio. Little of the coal from the district is sold to retailers for the domestic trade, and but relatively small quantities to public utilities. The railroads and industrial plants are the principal consumers of coal from the Fairmont district.

Distribution of coal produced in Fairmont district, W. Va., in 1917–18.

	Quantity (net tons).		Percentage of total.	
	1917	1918	1917	1918
Used in West Virginia:				
Sold to local trade, not shipped	563,559	521,470		
Used at mines for steam and heat	346,393	328,414		
Made into coke at mines	1,164,196	1,308,447		
Shipped to West Virginia points	526,778	569,025		
	2,600,926	2,727,356	14.8	13.6
Shipped to other States:				
Delaware	48,000	99,239		
District of Columbia	140,000	31,047		
Illinois	30,000	2,915		
Indiana	60,000	28,836		
Maryland	410,000	489,893		
Michigan	261,000	198,445		
New England	81,000	98,995		
New Jersey	750,000	849,600		
New York	358,000	423,914		
Ohio	523,000	208,402		
Pennsylvania	2,553,000	3,312,358		
Virginia	32,000	36,270		
Wisconsin	.....	4,736		
Lake vessel fuel	.....	13,665		
	5,246,000	5,798,315	29.8	28.8
Delivered to railroads by all-rail routes	5,862,206	6,364,777	33.4	31.7
Exported by rail	130,000	155,075	.7	.8
Shipped to tidewater	2,699,242	3,741,539	15.4	18.6
Shipped to Great Lakes for cargo	1,029,201	1,317,284	5.9	6.5
	17,567,575	20,104,346	100.0	100.0

NEW RIVER FIELD, W. VA.

The limitations placed on westbound shipments of the smokeless coal produced in the New River field by the zone system is reflected in the statistics of distribution for 1918, compared with 1917. Shipments to Illinois decreased from 275,000 net tons in 1917 to about 11,000 tons in 1918, and the decrease in shipments to Indiana, Michigan, and Ohio ranged from about 50 to more than 80 per cent. Shipments to Virginia were more than doubled, and increased quantities of New River coal were supplied to North Carolina and South

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Carolina and to the railroads for fuel. Tidewater dumpings of New River coal were slightly greater in 1918 than in 1917, but shipments to lower Lake Erie ports declined from 578,000 to 361,000 tons. The record for 1918 was largely determined by the policy of the Fuel Administration, which, after April 1, 1918, directed the movement. Smokeless coal from southern West Virginia was reserved for tidewater business and diverted from the New River field in large measure to supply the needs of industry and the householder in Virginia and the Carolinas, which constitute what is known as the "inland east" market. The coal from this field that moved westward after April 1, 1918, was shipped under permit for special purposes, as the manufacture of by-product coke and smithing.

Distribution of coal produced in New River field, W. Va., in 1917–18.

	Quantity (net tons).		Percentage of total.	
	1917	1918	1917	1918
Used in West Virginia:				
Sold to local trade, not shipped	319,182	337,924		
Used at mines for steam and heat	166,878	172,688		
Made into coke at mines	448,941	390,278		
Shipped to West Virginia points	209,645	221,160		
	1,144,646	1,122,050	7.6	7.8
Shipped to other States:				
District of Columbia	244,000	222,430		
Georgia	.....	2,275		
Illinois	275,000	10,895		
Indiana	260,000	136,360		
Kentucky	20,000	22,880		
Michigan	309,000	64,026		
North Carolina	357,000	478,150		
Ohio	950,000	160,960		
Pennsylvania	.....	138		
South Carolina	201,000	215,455		
Virginia	596,000	1,294,323		
Wisconsin	.....	25,786		
Miscellaneous	60,000	62,010		
	3,272,000	2,695,688	21.7	18.7
Delivered to railroads by all-rail routes	897,178	980,791	5.9	6.8
Exported by rail	2,000	1,278	.1	.1
Shipped to tidewater	9,201,898	9,286,536	60.9	64.1
Shipped to Great Lakes for cargo	578,314	361,450	3.8	2.5
	15,096,036	14,447,793	100.0	100.0

POCAHONTAS AND TUG RIVER FIELDS, W. VA.

The control of the distribution of Pocahontas coal was one of the most important items in the program of the Fuel Administration. From this field comes largely the low-volatile coal that is so essential to the manufacture of by-product coke and the fuel for bunkering ships. Before the war Pocahontas coal was used extensively as domestic fuel in the Middle West, notably in Chicago and in Ohio and Michigan. New England had been a large consumer of smokeless coal from both the Pocahontas and the New River fields. The great growth of the by-product coke industry, particularly in Ohio, Illinois, and Indiana, the enlarged demands of the Army and the Navy transport service, and the new burden of supplying the immense

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powder plant at Hopewell, Va.—a single requirement of 1,500,000 net tons annually—necessitated the curtailment of the use of Pocahontas coal in other directions.

By denying this coal to Chicago and vicinity, except for making by-product coke, the rail movement to Illinois was decreased from 2,650,000 tons in 1917 to 969,000 tons in 1918. More than half of the coal thus made available was absorbed by the coke ovens in Indiana. The use of smokeless coal for domestic purposes was prohibited in the Northwest, and the Lake cargo shipments were reduced nearly 1,000,000 tons. Shipments to Ohio and Michigan were almost entirely confined to coal for special uses and were made only by permit, with the result that each of those States received much less Pocahontas coal in 1918 than in 1917. On the other hand, increased quantities were supplied to North Carolina and South Carolina, Maryland, and the District of Columbia.

The gain in tidewater shipments of about 1,500,000 tons, or nearly 25 per cent, was a necessary part of the Fuel Administration's program, and was accomplished despite a decline in total production of 1,800,000 tons, or 7 per cent.

Distribution of coal produced in Pocahontas and Tug River fields, W. Va., in 1917–18.

	Quantity (net tons).		Percentage of total.	
	1917	1918	1917	1918
Used in West Virginia:				
Sold to local trade, not shipped	346,865	284,426		
Used at mines for steam and heat	312,708	326,137		
Made into coke at mines	2,820,384	2,411,346		
Shipped to West Virginia points	182,666	234,260		
	3,662,623	3,256,169	14.68	14.08
Used in Virginia:				
Sold to local trade, not shipped	94,696	49,297		
Used at mines for steam and heat	56,305	31,869		
Made into coke at mines	80,606	73,226		
Shipped to Virginia points	1,826,000	1,917,295		
	2,057,607	2,071,687	8.25	8.96
Shipped to other States:				
District of Columbia	2,000	20,000		
Illinois	2,650,000	969,081		
Indiana	1,947,000	2,907,241		
Kentucky	75,000	37,635		
Maryland	1,000	27,060		
Michigan	793,000	467,046		
Missouri	102,000	50,992		
North Carolina	311,000	420,225		
Ohio	2,502,000	1,562,924		
Pennsylvania	.....	261		
South Carolina	100,000	113,750		
Wisconsin	345,000	5,538		
Miscellaneous	20,000	.....		
	8,938,000	6,581,753	35.83	28.45
Delivered to railroads by all-rail routes	1,250,967	1,541,063	5.01	6.66
Exported by rail	168,000	172,443	.67	.75
Shipped to tidewater	6,294,209	7,854,855	25.23	33.96
Shipped to Great Lakes for cargo	2,575,956	1,650,265	10.33	7.14
	24,947,362	23,128,235	100.00	100.00

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SOUTHWESTERN VIRGINIA.

The principal features of the distribution of coal from southwestern Virginia in 1918 were the more or less widespread shipments of coal for special uses, as gas making, by permit under the zone system of the Fuel Administration, and the increased shipments to southern markets to supplement the decreased supplies from Alabama. Deliveries to consumers in Florida, Georgia, North Carolina, and South Carolina, and to the railroads for fuel, increased, but deliveries to tidewater decreased slightly. Deliveries to retail dealers were about the same as those to public utilities and not much less than deliveries to industrial consumers.

Distribution of coal produced in southwestern Virginia in 1917–18.

	Quantity (net tons).		Percentage of total.	
	1917	1918	1917	1918
Used in Virginia:				
Sold to local trade, not shipped	78,839	343,415		
Used at mines for steam and heat	88,926	75,650		
Made into coke at mines	1,954,093	1,527,849		
Shipped to Virginia points	883,371	1,016,971		
	3,005,229	2,963,885	34.9	32.8
Shipped to other States:				
Alabama	15,000	12,285		
Colorado		4,000		
California		5,135		
District of Columbia		20,115		
Florida	51,000	80,292		
Georgia	200,000	277,910		
Illinois	74,000	10,308		
Indiana	115,000	97,786		
Kentucky	11,000	10,010		
Louisiana		845		
Michigan	84,000	52,177		
North Carolina	753,000	899,339		
Ohio	78,000	48,566		
South Carolina	560,000	754,291		
Tennessee	360,000	314,661		
Texas	2,000	6,185		
West Virginia	50,000	45,240		
Wisconsin		54		
	2,353,000	2,639,199	27.3	29.2
Delivered to railroads by all-rail routes	2,657,491	2,872,154	30.9	31.8
Exported by rail		996		
Shipped to tidewater	582,781	564,558	6.7	6.2
Shipped to Great Lakes for cargo	5,817		.2	
	8,604,318	9,040,792	100.0	100.0

SOMERSET AND CUMBERLAND-PIEDMONT DISTRICTS, PA., MD., AND W. VA.

In order of quantity taken the principal markets reached by coal from the Somerset-Cumberland-Piedmont field are tidewater, Pennsylvania, Maryland, New Jersey, the District of Columbia, and the railroads for fuel. Smaller quantities go to other States, both near and far. The well-known Georges Creek blacksmithing coal is produced in the Cumberland-Piedmont district and in normal times is widely distributed.

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Distribution of coal produced in Somerset and Cumberland-Piedmont districts, Pa., Md., W. Va., in 1917–18.

	Quantity (net tons).		Percentage of total.	
	1917	1918	1917	1918
Used in Pennsylvania:				
Sold to local trade, not shipped	246,622	202,173		
Used at mines for steam and heat	209,250	207,610		
Made into coke at mines				
Shipped to Pennsylvania points	2,315,294	2,718,515		
	2,771,166	3,128,298	19.98	21.92
Used in Maryland:				
Sold to local trade, not shipped	104,578	98,288		
Used at mines for steam and heat	58,910	55,716		
Made into coke at mines				
Shipped to Maryland points	1,792,413	1,333,948		
	1,955,901	1,487,952	14.13	10.42
Used in West Virginia:				
Sold to local trade, not shipped	22,007	25,878		
Used at mines for steam and heat	39,431	48,277		
Made into coke at mines	19,104	16,260		
Shipped to West Virginia points	117,000	122,005		
	197,542	212,420	1.43	1.49
Shipped to other States:				
Delaware	96,000	164,645		
District of Columbia	448,000	854,973		
Illinois	15,000	10,541		
Indiana	1,000	8,505		
Michigan	5,000	15,408		
Missouri	10,000	7,685		
New England	339,000	109,005		
New Jersey	779,000	852,280		
New York	100,000	137,410		
Ohio	236,000	162,879		
Virginia	41,000	41,145		
Wisconsin		1,518		
Miscellaneous	100,000	146,770		
	2,170,000	2,512,764	15.67	17.62
Delivered to railroads by all-rail routes	1,562,890	759,010	11.33	5.31
Exported by rail	7,000	228	.05	
Shipped to tidewater	5,127,529	6,166,553	37.04	43.24
Shipped to Great Lakes for cargo	51,210		.37	
	13,843,238	14,267,225	100.00	100.00

ALABAMA.

The program of the Fuel Administration did not contemplate material reduction in 1918 of the area in which coal from Alabama is normally distributed but rather planned to take care of the industrial and other needs of the State of Alabama primarily with Alabama coal and to supplement the shipments from this State to other near-by markets that are normally dependent on coal from Alabama by supplies from other fields, such as Tennessee, Virginia, and western Kentucky. How this program worked out is shown by the statistics of distribution for 1917 and 1918. As in 1917, more than half the coal produced in Alabama in 1918 was used in the State. With the exception of those to Florida, shipments to all other States were less in 1918 than in 1917, as were deliveries to railroads. The special efforts of the Fuel Administration to increase the use of Alabama coal at tidewater points, for the relief of northern ports, resulted in an increase of deliveries to tidewater of more than 200,000 tons.

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Distribution of coal produced in Alabama in 1917–18.

	Quantity (net tons).		Percentage of total.	
	1917	1918	1917	1918
Used in Alabama:				
Sold to local trade, not shipped	508,398	304,038		
Used at mines for steam and heat	641,733	593,739		
Made into coke at mines	3,645,227	2,225,194		
Shipped to Alabama points	6,427,558	8,504,724		
	11,222,916	11,627,695	55.9	60.7
Shipped to other States:				
Arkansas	15,000	1,512		
Florida	115,000	173,290		
Georgia	585,000	556,585		
Louisiana	925,000	360,700		
Mississippi	750,000	341,575		
Missouri	7,000	.....		
Tennessee	175,000	94,575		
Texas	50,000	35,230		
	2,622,000	1,563,467	13.1	8.1
Delivered to railroads by all-rail routes	5,641,254	5,207,184	28.1	27.1
Shipped to tidewater	581,904	786,616	2.9	4.1
	20,068,074	19,184,962	100.0	100.0

TENNESSEE AND GEORGIA.

The control exercised by the Fuel Administration in 1918 had the effect of concentrating the distribution of coal from Tennessee in a smaller area than was recorded for 1917. Illinois, Iowa, Minnesota, Missouri, Texas, and Wisconsin, to which shipments were made in 1917, received no coal from this field in 1918, and the deliveries to consumers in Arkansas, Indiana, Kentucky, Louisiana, Michigan, and notably Ohio were reduced as a result of the requirements of the Fuel Administration that the coal be shipped to southern markets.

Distribution of coal produced in Tennessee and Georgia in 1917–18.

	Quantity (net tons).		Percentage of total.	
	1917	1918	1917	1918
Used in Tennessee:				
Sold to local trade, not shipped	135,348	148,130		
Used at mines for steam and heat	164,698	181,901		
Made into coke at mines	723,589	596,424		
Shipped to Tennessee points	1,184,383	1,347,924		
	2,208,018	2,274,379	35.0	33.0
Used in Georgia:				
Sold to local trade, not shipped	1,284	888		
Used at mines for steam and heat	7,200	6,250		
Made into coke at mines	72,689	37,853		
Shipped to Georgia points	680,000	700,915		
	761,173	745,906	12.1	10.8
Shipped to other States:				
Alabama	66,000	217,244		
Arkansas	3,000	2,105		
Florida	25,000	17,810		
Illinois	45,000	.....		
Indiana	45,000	4,225		
Iowa	9,000	.....		
Kentucky	27,000	12,675		
Louisiana	12,000	2,120		
Michigan	57,000	11,635		
Minnesota	9,000	.....		
Missouri	6,000	.....		
North Carolina	233,000	259,016		
Ohio	188,000	5,005		
South Carolina	135,000	135,200		
Texas	3,000	.....		
Wisconsin	9,000	.....		
	872,000	667,035	13.8	9.7
Delivered to railroads by all-rail routes	2,457,870	3,209,223	38.9	46.5
Shipped to tidewater	14,188	1,124	.2	.....
Shipped to Great Lakes for cargo	.....	97	.....	.....
	6,313,249	6,897,764	100.0	100.0

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CONNELLSVILLE DISTRICT, PA.

The Connellsville district is preeminently a source of beehive coke and of late years has been a source of coal for the manufacture of by-product coke. More than 79.3 per cent of the coal produced in this district is used in Pennsylvania, largely in the manufacture of coke at the mines, and the greater part of that shipped goes to by-product coke-oven plants and industries requiring a gas coal of high grade. Less Connellsville coal (including that coked at the mines) was used in Pennsylvania in 1918 than in 1917, owing to a lessened use of beehive ovens, the coal coked at the mines decreasing nearly 2,000,000 tons. Shipments to consumers in Pennsylvania increased nearly 50 per cent, and shipments in 1918 to consumers in New Jersey, New York, and Ohio (where the manufacture of by-product coke was being rapidly developed) were in excess of those in 1917.

Distribution of coal produced in Connellsville district, Pa., in 1917–18.

	Quantity (net tons).		Percentage of total.	
	1917	1918	1917	1918
Used in Pennsylvania:				
Sold to local trade, not shipped	534,362	400,478		
Used at mines for steam and heat	799,058	878,678		
Made into coke at mines	26,511,494	24,763,874		
Shipped to Pennsylvania points	1,510,760	2,234,338		
	29,355,674	28,277,368	84.8	79.4
Shipped to other States:				
Delaware	30,000	24,245		
Illinois	.....	3,944		
Indiana	.....	5,249		
Maryland	149,000	132,795		
Michigan	.....	23,406		
New England	400,000	356,655		
New Jersey	300,000	382,850		
New York	350,000	607,880		
Ohio	2,000,000	2,373,121		
West Virginia	150,000	238,860		
	3,379,000	4,149,005	9.8	11.6
Delivered to railroads by all-rail routes	1,246,737	2,042,219	3.6	5.7
Exported by rail	161,000	231,300	.5	.6
Shipped to tidewater	454,492	517,248	1.3	1.4
Shipped to Great Lakes for cargo	.....	458,360	.....	1.3
	34,596,903	35,676,500	100.0	100.0

PITTSBURGH, PA., AND PANHANDLE OF WEST VIRGINIA.

There were no material changes in the distribution of coal from the Pittsburgh district in 1918. Approximately the same quantities were supplied to the more important markets in 1918 as in 1917, except New Jersey and New York, which received decreased shipments. One-half of the increase in total production was taken by the railroads, which use about 10 per cent of the coal from this field. The principal markets are railroad fuel, the Northwest by way of the Great Lakes, Canada, Pennsylvania, New Jersey, New York, and Ohio. The Pittsburgh industrial district is of course the largest single market, and in western Pennsylvania coal from the Pittsburgh district is used for domestic purposes and by public utilities.

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Distribution of coal produced in Pittsburgh, Pa., and Panhandle of West Virginia in 1917–18.

	Quantity (net tons).		Percentage of total.	
	1917	1918	1917	1918
Used in Pennsylvania:				
Sold to local trade, not shipped	1,600,487	1,926,011		
Used at mines for steam and heat	806,627	827,845		
Made into coke at mines	1,529,748	1,544,478		
Shipped to Pennsylvania points	16,931,802	17,035,788		
	20,868,664	21,334,122	41.99	41.36
Used in West Virginia:				
Sold to local trade, not shipped	792,686	967,835		
Used at mines for steam and heat	49,516	37,723		
Made into coke at mines	.....	.....		
Shipped to West Virginia points	750,000	808,015		
	1,592,202	1,813,573	3.16	3.52
Shipped to other States:				
Delaware	10,000	12,350		
Illinois	55,000	2,955		
Indiana	112,000	205,620		
Maryland	.....	7,110		
Michigan	290,000	375,259		
New England	450,000	423,670		
New Jersey	1,170,000	1,054,365		
New York	4,130,000	3,279,315		
Ohio	6,819,000	6,916,510		
Wisconsin	18,000	1,728		
Lake vessel fuel	.....	884,216		
	13,054,000	13,163,098	25.81	25.55
Delivered to railroads by all-rail routes	5,045,018	5,587,177	9.97	10.84
Exported by rail	2,289,000	2,298,676	3.78	4.46
Shipped to tidewater	379,438	277,534	.75	.54
Shipped to Great Lakes for cargo	7,359,447	7,080,162	14.55	13.73
	50,587,769	51,554,342	100.00	100.00

NORTHERN OHIO.

The increase of 3,400,000 tons in production in 1918 in the fields here designated northern Ohio was largely delivered to consumers in Ohio, Michigan, Canada (by rail), and the Northwest (by way of the Great Lakes). To make available additional coal for the Lakes the Fuel Administration arranged in the summer of 1918 for the transfer of certain railroad requirements from Ohio to Indiana, which accounts for the decrease in deliveries of railroad fuel coal from northern Ohio.

Distribution of coal produced in northern Ohio in 1917–18.

	Quantity (net tons).		Percentage of total.	
	1917	1918	1917	1918
Used in Ohio:				
Sold to local trade, not shipped	1,919,660	1,561,179		
Used at mines for steam and heat	471,044	602,573		
Made into coke at mines	630	.....		
Shipped to Ohio points	8,922,713	10,034,676		
	11,314,047	12,198,428	43.6	40.3
Shipped to other States:				
Illinois	25,000	9,450		
Indiana	146,000	113,751		
Michigan	810,000	1,618,163		
Minnesota	50,000	.....		
New York	350,000	373,740		
Pennsylvania	160,000	67,082		
West Virginia	10,000	38,332		
Wisconsin	25,000	20,697		
Lake vessel fuel	.....	416,080		
	1,576,000	2,657,295	5.9	8.8
Delivered to railroads by all-rail routes	7,088,626	6,939,032	26.4	22.9
Exported by rail	1,921,000	2,155,893	5.7	7.1
Shipped to tidewater	36,059	15,523	.....	.1
Shipped to Great Lakes for cargo	4,913,771	6,320,513	18.4	20.8
	26,849,503	30,286,684	100.0	100.0

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SOUTHERN OHIO.

The distribution of coal from southern Ohio in 1918 was, by the zones established by the Fuel Administration, confined within narrower limits than in 1917. This was particularly true as regards Michigan, from the western fourth of which southern Ohio coal was excluded, and for a part of the year this coal, except for domestic consumers, was excluded from the other States which it reaches under normal conditions. The prohibition of shipments to eastern Indiana does not appear to have affected the distribution to any great extent, as the shipments to Indiana in 1918 amounted to 147,000 tons, compared with 162,000 tons in 1917. Notwithstanding the restriction in movement of Ohio coal to Michigan, the southern Ohio district recorded a gain in that market. A substantial increase in shipments to consumers in Ohio was also recorded. Shipments to the Lakes for cargo were increased more than 300,000 tons, as a result of the restrictions of distribution into Michigan placed by the Fuel Administration and of certain transfers of requirements of railroad fuel from the southern Ohio district to Indiana fields. In other words, the gain in Lake shipments was effected, at least in part, by a decrease in deliveries to railroads for fuel.

Distribution of coal produced in southern Ohio in 1917–18.

	Quantity (net tons).		Percentage of total.	
	1917	1918	1917	1918
Used in Ohio:				
Sold to local trade, not shipped	614,684	454,541		
Used at mines for steam and heat	280,237	306,040		
Shipped to Ohio points	3,412,417	4,771,365		
	4,307,338	5,531,946	30.5	35.1
Used in West Virginia:				
Sold to local trade, not shipped	26,665	73,886		
Used at mines for steam and heat	9,751	12,495		
Shipped to West Virginia points	35,000	36,065		
	71,416	122,446	.5	.8
Shipped to other States:				
Illinois	65,000	26,272		
Indiana	162,000	146,771		
Michigan	1,969,000	2,511,074		
Wisconsin	25,000	10,171		
Lake vessel fuel	.....	154,611		
	2,221,000	2,848,899	15.8	18.0
Delivered to railroads by all-rail routes	4,485,028	3,826,636	31.8	24.3
Exported by rail	106,000	221,388	.8	1.4
Shipped to Great Lakes for cargo	2,907,625	3,216,221	20.6	20.4
	14,098,407	15,767,536	100.0	100.0

MICHIGAN.

Coal from mines in Michigan to the extent of nearly 200,000 tons more than in 1917 was delivered to consumers in the State in 1918, as a result of a slightly greater production and a decrease in the deliveries to railroads for fuel.

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Distribution of coal produced in Michigan in 1917–18.

	Quantity (net tons).		Percentage of total.	
	1917	1918	1917	1918
Used in Michigan:				
Sold to local trade, not shipped	.....	98,954		
Used at mines for steam and heat	47,965	85,206		
Made into coke at mines	82,045	.....		
Shipped to Michigan points	883,948	1,006,337		
	1,013,958	1,190,497	73.8	81.3
Delivered to railroads by all-rail routes	360,847	274,321	26.2	18.7
	1,374,805	1,464,818	100.0	100.0

NORTHEASTERN KENTUCKY.

The coal from northeastern Kentucky in 1918 was distributed largely in the same markets as in 1917, with the difference, however, that within those market areas the coal was to a considerable extent diverted from steam and domestic uses to manufacturers of by-product coke and other consumers of high-grade gas coal. A small increase in production and decreased shipments to Illinois, Iowa, Kansas, Minnesota, Nebraska, North Carolina, South Dakota, Tennessee, and Wisconsin furnished increased supplies for Indiana, Kentucky, Michigan, Ohio, and Canada, where coal of the special quality produced in this field was needed for such purposes as the manufacture of by-product coke.

Distribution of coal produced in northeastern Kentucky in 1917–18.

	Quantity (net tons).		Percentage of total.	
	1917	1918	1917	1918
Used in Kentucky:				
Sold to local trade, not shipped	103,779	154,663		
Used at mines for steam and heat	128,077	131,212		
Made into coke at mines	198,934	167,346		
Shipped to Kentucky points	384,611	687,251		
	815,401	1,140,472	12.6	16.0
Shipped to other States:				
Florida	3,000	7,405		
Georgia	.....	4,680		
Illinois	428,000	241,407		
Indiana	900,000	1,172,668		
Iowa	198,000	40,300		
Kansas	27,000	.....		
Michigan	797,000	803,819		
Minnesota	195,000	.....		
Missouri	270,000	448,680		
Nebraska	45,000	.....		
North Carolina	15,000	13,715		
Ohio	1,265,000	1,655,285		
Pennsylvania	.....	20,641		
South Carolina	.....	17,420		
South Dakota	60,000	.....		
Tennessee	2,000	.....		
Wisconsin	25,000	7,313		
Lake vessel fuel	.....	18,991		
	4,230,000	4,452,324	65.6	62.7
Delivered to railroads by all-rail routes	514,675	585,976	7.9	8.2
Exported by rail	37,000	125,235	.6	1.8
Shipped to Great Lakes for cargo	856,603	804,809	13.3	11.3
	6,453,679	7,108,816	100.0	100.0

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HAZARD DISTRICT, KY.

Shipments of coal from the Hazard district, Ky., in 1918 to all the principal markets were greater than in 1917.

Distribution of coal produced in Hazard district, Ky., in 1917–18.

	Quantity (net tons).		Percentage of total.	
	1917	1918	1917	1918
Used in Kentucky:				
Sold to local trade, not shipped	41,362	31,802		
Used at mines for steam and heat	10,371	9,380		
Shipped to Kentucky points	102,018	250,903		
	153,751	292,085	8.4	12.4
Shipped to other States:				
Illinois	25,000	40,596		
Indiana	172,000	264,700		
Michigan	295,000	350,190		
New England	.....	150		
New Jersey	.....	1,222		
New York	.....	3,373		
Ohio	784,000	824,277		
Wisconsin	.....	515		
	1,276,000	1,485,023	69.5	62.7
Delivered to railroads by all-rail routes	254,836	314,940	13.9	13.3
Exported by rail	3,000	1,386	.2	.1
Shipped to Great Lakes for Cargo	147,766	270,902	8.0	11.5
	1,835,353	2,364,336	100.0	100.0

SOUTHEASTERN KENTUCKY.

One of the effects of the control by the Fuel Administration in 1918 of the distribution of coal from southeastern Kentucky was the reduction in movement to such Central States as Iowa, Kansas, South Dakota, and Minnesota, and increases to markets in the South—Florida, Georgia, Tennessee, North Carolina, and South Carolina—and in the North—Illinois, Indiana, Michigan, and Ohio. A considerable portion of the commercial shipments from this field go to retail dealers, and except the gas coal for the manufacture of by-product coke and other special uses and railroad fuel, coal for domestic use forms the largest item in the output from this district.

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Distribution of coal produced in southeastern Kentucky in 1917–18.

	Quantity (net tons).		Percentage of total	
	1917	1918	1917	1918
Used in Kentucky:				
Sold to local trade, not shipped	124,846	190,899		
Used at mines for steam and heat	113,333	140,718		
Made into coke at mines	279,623	281,443		
Shipped to Kentucky points	949,480	798,125		
	1,467,282	1,411,185	22.9	17.5
Shipped to other States:				
Alabama	50,000	.....		
Florida	44,000	54,080		
Georgia	1,070,000	1,294,245		
Illinois	228,000	353,095		
Indiana	338,000	575,861		
Iowa	36,000	12,610		
Kansas	27,000	.....		
Louisiana	81,000	.....		
Michigan	445,000	744,475		
Minnesota	33,000	.....		
Missouri	16,000	6,110		
North Carolina	91,000	144,885		
Ohio	477,000	804,912		
Pennsylvania	.....	349		
South Carolina	72,000	293,800		
South Dakota	24,000	.....		
Tennessee	459,000	540,215		
Texas	27,000	.....		
Virginia	10,000	6,045		
Wisconsin	57,000	280		
	3,585,000	4,830,962	56.2	59.8
Delivered to railroads by all-rail routes	1,103,865	1,588,246	17.3	19.6
Exported by rail	4,000	205	.1	.....
Shipped to tidewater	36,600	13,223	.6	.2
Shipped to Great Lakes for cargo	184,397	238,843	2.9	2.9
	6,381,144	8,082,664	100.0	100.0

KANAWHA AND KENOVA-THACKER DISTRICTS, W. VA., KY.

The effect of the control exercised by the Fuel Administration in 1918 on the distribution of coal from the Kanawha and Kenova-Thacker districts is indicated in the following table. In 1917 shipments were made to 18 States (other than West Virginia and Kentucky, where the coal is produced); in 1918 to 12 States. No all-rail shipments were made in 1918 to Delaware, Minnesota, Missouri, Nebraska, New York, or South Dakota, each of which received coal from this field in 1917. Shipments to all other Central States, as Illinois, Iowa, and Wisconsin, were limited to coal for special purposes and were less in 1918 than in 1917. There were notable increases in the movement of coal from these districts to Michigan and Ohio, on the west, mainly in coal for domestic use. About one-fourth of the coal sold through retailers in Michigan and nearly one-fifth of that sold in Ohio in 1918 came from these districts. Of the all-rail commercial shipments, about 22 per cent is sold to retail dealers.

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Distribution of coal produced in Kanawha and Kenova-Thacker districts, W. Va., Ky., in 1917–18.

	Quantity (net tons).		Percentage of total.	
	1917	1918	1917	1918
Used in West Virginia:				
Sold to local trade, not shipped	423,429	425,366		
Used at mines for steam and heat	270,274	234,217		
Made into coke at mines	303,000	432,856		
Shipped to West Virginia points	286,615	401,635		
	1,283,318	1,494,074	4 60	4 87
Used in Kentucky:				
Sold to local trade, not shipped	90,939	51,177		
Used at mines for steam and heat	43,580	35,575		
Shipped to Kentucky points	569,000	531,375		
	703,519	618,127	2 52	2 02
Shipped to other States:				
Delaware	3,000	.....		
District of Columbia	3,000	6,209		
Illinois	543,000	332,301		
Indiana	897,000	1,176,905		
Iowa	165,000	28,974		
Michigan	3,510,000	4,963,432		
Minnesota	60,000	.....		
Missouri	20,000	.....		
Nebraska	6,000	.....		
New Jersey	25,000	65,975		
New York	3,000	.....		
North Carolina	338,000	377,715		
Ohio	4,987,000	7,016,193		
Pennsylvania	250,000	321,620		
South Carolina	110,000	66,557		
South Dakota	15,000	.....		
Virginia	730,000	713,130		
Wisconsin	963,000	110,423		
Lake vessel fuel	.....	122,115		
	12,628,000	15,361,549	45.34	50.11
Delivered to railroads by all-rail routes	5,601,077	5,681,786	20.10	18.53
Exported by rail	185,000	310,297	.66	1.01
Shipped to tidewater	1,389,026	1,362,963	4.98	4.45
Shipped to Great Lakes for cargo	6,074,183	5,826,384	21.80	19.01
	27,864,123	30,655,180	100.0	100.00

WESTERN KENTUCKY.

Compared with 1917, there were reductions in the shipments of coal from western Kentucky in 1918 to markets in Alabama and Texas in the South, and to Illinois, Indiana, Iowa, Missouri, Nebraska, South Dakota, and Wisconsin, in the North and West. Shipments to Ohio were also less in 1918 than in 1917. These reductions were due to the policy of the Fuel Administration of confining the distribution of coal from the western Kentucky field generally to southern markets. Notable increases in deliveries to consumers in Mississippi and Tennessee and small gains in Arkansas and Louisiana were recorded in 1918. The largest increase was in the deliveries of coal to railroads, which showed a gain of 41 per cent.

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Distribution of coal produced in western Kentucky in 1917–18.

	Quantity (net tons).		Percentage of total.	
	1917	1918	1917	1918
Used in Kentucky:				
Sold to local trade, not shipped	532,654	621,444		
Used at mines for steam and heat	344,616	361,205		
Made into coke at mines	121,059	84,812		
Shipped to Kentucky points	1,988,171	1,742,267		
	2,986,500	2,809,728	29.1	25.9
Shipped to other States:				
Alabama	100,000	97,434		
Arkansas	102,000	106,404		
Illinois	447,000	105,638		
Indiana	720,000	266,434		
Iowa	63,000	15,046		
Kansas	15,000	3,145		
Louisiana	669,000	676,134		
Michigan	.....	46		
Minnesota	.....	92		
Mississippi	551,000	755,734		
Missouri	214,000	62,598		
Nebraska	36,000	.....		
Ohio	30,000	22,616		
South Dakota	3,000	.....		
Tennessee	1,192,000	1,679,058		
Texas	42,000	19,498		
Wisconsin	110,000	26,304		
	4,294,000	3,836,231	41.9	35.4
Delivered to railroads by all-rail routes	2,966,930	4,176,775	29.0	38.6
Shipped to tidewater	2,050	10,500	.0	.1
	10,249,480	10,833,234	100.0	100.0

INDIANA.

Notable increases in the shipment of coal from Indiana to consumers in the State, to Illinois and Michigan, and to the railroads for fuel were made in 1918. The increase in total production of more than 4,000,000 tons was distributed in the markets named. The States to which, either in whole or in part, coal from Indiana was denied by the Fuel Administration under the zone plan, as Iowa, Minnesota, and Missouri, are shown in the following table to have received less coal from this State. The small shipments recorded were either delivered before the zone system became effective on April 1, 1918, or were forwarded under permit for special purposes. Deliveries to retail dealers represent an important part of the business of the shippers of coal from Indiana, and during the summer and early fall of 1918 these deliveries were larger than normal, but they decreased after the armistice was signed and during the mild winter.

Distribution of coal produced in Indiana in 1917–18.

	Quantity (net tons).		Percentage of total.	
	1917	1918	1917	1918
Used in Indiana:				
Sold to local trade, not shipped	905,601	941,707		
Used at mines for steam and heat	642,551	775,276		
Shipped to Indiana points	10,293,146	11,286,804		
	11,841,298	13,003,787	44.6	42.5

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Distribution of coal produced in Indiana in 1917–18—Continued.

	Quantity (net tons.)		Percentage of total.	
	1917	1918	1917	1918
Shipped to other States:				
Arkansas	.....	150		
Georgia	.....	550		
Illinois	5,165,000	6,015,607		
Iowa	.....	89,796		
Kansas	247,000	96		
Kentucky	136,000	104,784		
Louisiana	.....	23,232		
Michigan	674,000	1,739,424		
Minnesota	199,000	27,792		
Mississippi	.....	96		
Missouri	54,000	1,903		
Nebraska	9,000	1,932		
North Dakota	3,000	240		
Ohio	134,000	39,664		
South Dakota	15,000	576		
Tennessee	.....	2,284		
Wisconsin	564,000	617,184		
	7,200,000	8,665,310	27.1	28.2
Delivered to railroads by all-rail routes	7,498,031	8,904,451	28.3	29.0
Exported by rail	.....	105,086	.....	.3
	26,539,329	30,678,634	100.0	100.0

ILLINOIS.

The production of coal in Illinois increased in 1918, compared with 1917, by more than 3,000,000 tons. For consumers in the State of Illinois deliveries were greater in 1918 by about 5,700,000 tons; total commercial shipments to other States were about the same in the two years, but deliveries to railroads were more than 3,000,000 tons less in 1918 than in 1917. A considerable portion of the coal in commercial shipments from Illinois normally goes to retail dealers, and in September and October that trade represented nearly half of the total.

Distribution of coal produced in Illinois in 1917–18.

	Quantity (net tons).		Percentage of total.	
	1917	1918	1917	1918
Used in Illinois:				
Sold to local trade, not shipped	3,541,792	3,641,044		
Used at mines for steam and heat	2,374,250	2,381,197		
Shipped to Illinois points	25,780,675	31,405,464		
	31,696,717	37,427,705	36.7	41.9
Shipped to other States:				
Alabama	.....	20,719		
Arkansas	96,000	267,628		
Indiana	2,255,000	2,410,432		
Iowa	4,026,000	3,597,048		
Kansas	107,000	46,767		
Kentucky	18,000	14,306		
Louisiana	102,000	86,112		
Michigan	706,000	983,572		
Minnesota	1,801,000	1,967,926		
Mississippi	55,000	22,954		
Missouri	6,806,000	6,830,419		
Nebraska	661,000	185,946		
North Dakota	43,000	7,820		
Ohio	63,000	16,000		
South Dakota	231,000	228,160		
Tennessee	50,000	210,128		
Texas	63,000	322		
Wisconsin	1,936,000	2,486,254		
	19,019,000	19,382,513	22.1	21.7
Delivered to railroads by all-rail routes	35,431,220	32,370,362	41.1	36.3
Exported by rail	50,000	95,125	.1	.1
Shipped to tidewater	2,450	15,400	.....	.....
	86,199,387	89,291,105	100.0	100.0

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ARKANSAS.

The distribution of coal produced in Arkansas for nine months of 1918, under the control of the Fuel Administration, was not greatly different from that recorded for 1917. Shipments were confined largely to markets nearer the mines, however, and no coal was shipped to such distant points as Minnesota.

Distribution of coal produced in Arkansas in 1917–18.

	Quantity (net tons).		Percentage of total.	
	1917	1918	1917	1918
Used in Arkansas:				
Sold to local trade, not shipped	59,104	41,457		
Used at mines for steam and heat	75,067	73,920		
Shipped to Arkansas points	537,297	506,539		
	671,468	621,916	31.3	27.9
Shipped to other States:				
Illinois	20,000	29,810		
Iowa	9,000	26,044		
Kansas	117,000	138,705		
Louisiana	31,000	27,804		
Minnesota	6,000	----------		
Missouri	250,000	251,153		
Nebraska	50,000	126,085		
Oklahoma	89,000	73,529		
Tennessee	35,000	11,266		
Texas	127,000	148,141		
	735,000	832,537	34.3	37.4
Delivered to railroads by all-rail routes	737,111	772,916	34.4	34.7
	2,143,579	2,227,369	100.0	100.0

IOWA.

The decrease in the production of coal in Iowa in 1918 was due largely to lack of demand from the railroads. Deliveries of Iowa coal for railroad fuel in 1918 showed a decrease of 700,000 tons. The prohibition of shipments of eastern coal west of the area immediately adjacent to the Mississippi gave shippers in Iowa opportunity to extend their markets. In 1918 Iowa coal was shipped to 10 other States, compared with 5 in 1917.

Distribution of coal produced in Iowa in 1917–18.

	Quantity (net tons).		Percentage of total.	
	1917	1918	1917	1918
Used in Iowa:				
Sold to local trade, not shipped	781,970	602,556		
Used at mines for steam and heat	226,394	190,609		
Shipped to Iowa points	2,876,137	3,026,262		
	3,887,501	3,819,427	43.4	46.6
Shipped to other States:				
Arkansas	----------	2,117		
Illinois	----------	1,703		
Kansas	15,000	14,265		
Louisiana	----------	138		
Minnesota	31,000	5,318		
Missouri	239,000	271,239		
Nebraska	130,000	163,073		
Oklahoma	----------	1,251		
South Dakota	30,000	15,948		
Texas	----------	90		
	445,000	475,145	5.0	5.8
Delivered to railroads by all-rail routes	4,633,329	3,897,623	51.6	47.6
	8,965,830	8,192,195	100.0	100.0

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MISSOURI.

There was little change recorded in the distribution of coal from Missouri in 1918, compared with 1917. Deliveries to consumers in Missouri declined, but shipments to other States increased, especially those to Arkansas, Iowa, Kansas, and Nebraska. Deliveries to the railroads were about the same in both years.

Distribution of coal produced in Missouri in 1917–18.

	Quantity (net tons).		Percentage of total.	
	1917	1918	1917	1918
Used in Missouri:				
Sold to local trade, not shipped	576,079	385,896		
Used at mines for steam and heat	151,781	162,243		
Shipped to Missouri points	2,386,733	2,333,761		
	3,114,593	2,881,900	54.9	50.9
Shipped to other States:				
Arkansas	.....	6,014		
Colorado	4,000	.....		
Iowa	58,000	93,216		
Kansas	261,000	309,403		
Nebraska	119,000	291,374		
Oklahoma	20,000	24,601		
South Dakota	.....	3,488		
	462,000	728,099	8.2	12.8
Delivered to railroads by all-rail routes	2,093,956	2,057,731	36.9	36.3
	5,670,549	5,667,730	100.0	100.0

KANSAS.

Deliveries of coal produced in Kansas to consumers in that State in 1918 were slightly less than in 1917, but shipments to other States, as Missouri, Nebraska, and Oklahoma, increased. The consumption of coal from Kansas by the railroads was about the same in both years.

Distribution of coal produced in Kansas in 1917–18.

	Quantity (net tons).		Percentage of total.	
	1917	1918	1917	1918
Used in Kansas:				
Sold to local trade, not shipped	161,004	173,330		
Used at mines for steam and heat	185,464	200,259		
Shipped to Kansas points	2,090,326	1,968,265		
	2,436,794	2,341,854	33.9	31.0
Shipped to other States:				
Arkansas	2,000	2,225		
Colorado	1,000	.....		
Illinois	.....	46		
Iowa	81,000	79,660		
Louisiana	.....	79		
Missouri	792,000	997,260		
Nebraska	556,000	748,126		
Oklahoma	116,000	145,078		
South Dakota	.....	1,271		
Texas	.....	2,916		
	1,548,000	1,976,661	21.6	26.1
Delivered to railroads by all-rail routes	3,200,181	3,243,432	44.5	42.9
	7,184,975	7,561,947	100.0	100.0

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OKLAHOMA.

Coal produced in Oklahoma and delivered to consumers in that State increased in 1918, and shipments to other States, particularly Arkansas, Kansas, Nebraska, New Mexico, and Texas, were also greater. The railroads used less coal from Oklahoma in 1918 than in 1917.

Distribution of coal produced in Oklahoma in 1917–18.

	Quantity (net tons).		Percentage of total.	
	1917	1918	1917	1918
Used in Oklahoma:				
Sold to local trade, not shipped	45,492	37,600		
Used at mines for steam and heat	189,190	207,917		
Shipped to Oklahoma points	1,244,331	1,435,617		
	1,479,013	1,681,134	33.7	34.9
Shipped to other States:				
Arkansas	10,000	81,011		
Illinois		750		
Iowa	2,000	10,983		
Kansas	51,000	98,004		
Louisiana	2,000	3,865		
Missouri	91,000	93,990		
Nebraska	12,000	31,069		
New Mexico	4,000	15,149		
Texas	408,000	554,503		
	580,000	889,324	13.2	18.5
Delivered to railroads by all-rail routes	2,327,831	2,242,989	53.1	46.6
	4,386,844	4,813,447	100.0	100.0

TEXAS.

The production of coal in Texas decreased slightly in 1918, mainly in shipments to tidewater and in exports by rail (to Mexico).

Distribution of coal produced in Texas in 1917–18.

	Quantity (net tons).		Percentage of total.	
	1917	1918	1917	1918
Used in Texas:				
Sold to local trade, not shipped	14,102	11,854		
Used at mines for steam and heat	49,355	45,015		
Shipped to Texas points	1,172,576	1,165,830		
	1,236,033	1,222,699	52.5	54.0
Shipped to other States:				
Nebraska		129		
New Mexico	2,000			
Oklahoma	5,000	6,632		
	7,000	6,761	.3	.3
Delivered to railroads by all-rail routes	952,051	941,874	40.4	41.7
Exported by rail	93,331	69,801	3.9	3.1
Shipped to tidewater	67,400	20,000	2.9	.9
	2,355,815	2,261,135	100.0	100.0

COLORADO.

The coal produced in Colorado in 1918 was more generally distributed outside the State than in 1917. Less coal from mines within the State was used in Colorado in 1918, but shipments to the railroads for fuel, and to certain other States increased. Among the States receiving increased quantities of Colorado coal were Iowa, Kansas, Nebraska, Oklahoma, and Texas.

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Distribution of coal produced in Colorado in 1917–18.

	Quantity (net tons).		Percentage of total.	
	1917	1918	1917	1918
Used in Colorado:				
Sold to local trade, not shipped	450,392	436,338		
Used at mines for steam and heat	304,492	311,009		
Made into coke at mines	[a] 1,957,923	1,079,413		
Shipped to Colorado points	4,584,232	4,519,046		
	7,297,039	6,345,806	58.5	51.1
Shipped to other States:				
Arizona	10,000	10,185		
California	30,000	5,335		
Idaho	.....	5,084		
Iowa	15,000	135,151		
Kansas	600,000	783,383		
Missouri	.....	5,612		
Nebraska	749,000	1,133,342		
New Mexico	168,000	82,829		
Oklahoma	90,000	145,139		
South Dakota	20,000	30,100		
Texas	378,000	399,132		
Utah	3,000	995		
Wyoming	75,000	54,266		
	2,138,000	2,790,553	17.1	22.5
Delivered to railroads by all-rail routes	3,088,297	3,246,855	24.4	26.2
Exported by rail	10,000	24,357	.....	.2
	12,483,336	12,407,571	100.0	100.0

[a] Includes approximately 1,215,000 tons of coal shipped to beehive coke ovens.

NEW MEXICO.

Increases in deliveries to consumers in New Mexico and in commercial shipments to other States are recorded in the distribution of coal produced in New Mexico in 1918. Deliveries to the railroads for fuel declined, but exports by rail (to Mexico) increased. Shipments to tidewater (Pacific coast ports) decreased.

Distribution of coal produced in New Mexico in 1917–18.

	Quantity (net tons).		Percentage of total.	
	1917	1918	1917	1918
Used in New Mexico:				
Sold to local trade, not shipped	44,636	39,075		
Used at mines for steam and heat	36,449	39,271		
Made into coke at mines	[a] 991,488	1,108,092		
Shipped to New Mexico points	199,424	217,277		
	1,271,997	1,403,715	31.8	34.9
Shipped to other States:				
Arizona	102,000	224,687		
California	85,000	56,355		
Colorado	72,000	54,210		
Kansas	94,000	78,390		
Oklahoma	24,000	31,330		
Texas	157,000	234,489		
	534,000	679,461	13.3	16.9
Delivered to railroads by all-rail routes	1,991,066	1,735,832	49.8	43.2
Exported by rail	60,464	74,231	1.5	1.8
Shipped to tidewater	143,000	130,000	3.6	3.2
	4,000,527	4,023,239	100.0	100.0

[a] Includes approximately 533,000 tons of coal shipped to beehive coke ovens.

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NORTH DAKOTA.

Lignite produced in North Dakota is almost entirely used within the State. About 4,300 tons was shipped to Minnesota in 1918; no shipments to that market were recorded in 1917.

Distribution of coal produced in North Dakota in 1917–18.

	Quantity (net tons).		Percentage of total.	
	1917	1918	1917	1918
Used in North Dakota:				
Sold to local trade, not shipped	196,900	173,744		
Used at mines for steam and heat	34,077	19,943		
Shipped to North Dakota points	521,216	497,950		
	752,193	691,637	95.2	96.1
Shipped to other States:				
Minnesota	.....	4,364		
South Dakota	12,000	10,126		
	12,000	14,490	1.5	2.0
Delivered to railroads by all-rail routes	26,355	13,606	3.3	1.9
	790,548	719,733	100.0	100.0

MONTANA AND NORTHERN WYOMING.

The distribution of coal from Montana and other Rocky Mountain and Pacific Coast States was in no way regulated by the zone system of the Fuel Administration. Increased quantities of coal from those fields were supplied in 1918, compared with 1917, to Montana, Wyoming, North Dakota, and South Dakota, as well as to the railroads for fuel. Shipments were made in 1918 to Colorado, Kansas, Minnesota, and Oregon; none of these States received coal from this region in 1917.

Distribution of coal produced in Montana and northern Wyoming in 1917–18.

	Quantity (net tons).		Percentage of total.	
	1917	1918	1917	1918
Used in Montana:				
Sold to local trade, not shipped	176,066	179,079		
Used at mines for steam and heat	167,704	175,532		
Shipped to Montana points	1,230,000	1,341,106		
	1,573,770	1,695,717	22.39	22.39
Used in Wyoming:				
Sold to local trade, not shipped	64,162	77,216		
Used at mines for steam and heat	97,803	89,818		
Shipped to Wyoming points	123,233	171,360		
	285,198	338,394	4.06	4.45
Shipped to other States:				
Colorado	.....	996		
Idaho	28,000	20,736		
Iowa	324,000	236,013		
Kansas	.....	1,332		
Minnesota	.....	14,582		
Missouri	20,000	13,536		
Nebraska	681,000	590,095		
North Dakota	96,000	154,080		
Oregon	.....	1,404		
South Dakota	191,000	250,800		
Washington	121,000	105,264		
	1,461,000	1,388,788	20.79	18.28
Delivered to railroads by all-rail routes	3,707,562	4,183,182	52.75	54.98
Exported by rail	1,000	47	.01	.....
	7,028,530	7,606,128	100.0	100.00

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UTAH AND SOUTHERN WYOMING.

The increase in the use of coal from Utah and southern Wyoming in 1918, compared with 1917, was general. The only States to which decreased shipments were made in 1918 were Iowa, Montana, and Nebraska. The railroads received over 18 per cent more than in 1917, and shipments to tide water (San Francisco) more than tripled.

Distribution of coal produced in Utah and southern Wyoming in 1917–18.

	Quantity (net tons).		Percentage of total.	
	1917	1918	1917	1918
Used in Utah:				
Sold to local trade, not shipped	77,028	64,827		
Used at mines for steam and heat	86,128	94,978		
Made into coke at mines	669,316	738,302		
Shipped to Utah points	1,378,000	1,786,155		
	2,210,472	2,684,262	22.33	23.33
Used in Wyoming:				
Sold to local trade, not shipped	61,322	53,561		
Used at mines for steam and heat	172,638	162,841		
Shipped to Wyoming points	159,737	201,206		
	393,697	417,608	3.98	3.63
Shipped to other States:				
California	590,000	653,766		
Colorado	6,000	17,479		
Idaho	499,000	543,544		
Iowa	54,000	46,622		
Kansas	10,000	14,739		
Missouri		1,690		
Montana	365,000	274,107		
Nebraska	353,000	344,083		
Nevada	362,000	444,656		
Oregon	220,000	267,241		
South Dakota		11,999		
Washington	137,000	156,900		
	2,596,000	2,776,816	26.22	21.14
Delivered to railroads by all-rail routes	4,675,978	5,553,320	47.24	48.29
Shipped to tidewater	22,861	69,884	.23	.61
	9,899,008	11,501,890	100.00	100.00

WASHINGTON.

The coal produced in Washington is used principally within the State, in Oregon, by the railroads, and for bunkers at tidewater in Puget Sound. Decreases in the demand in Oregon and by the railroads in 1918 were offset by increased demand in Washington and at tidewater, with the result that the production in 1918 was almost identical with that in 1917.

Distribution of coal produced in Washington in 1917–18.

	Quantity (net tons).		Percentage of total.	
	1917	1918	1917	1918
Used in Washington:				
Sold to local trade, not shipped	71,606	74,315		
Used at mines for steam and heat	166,399	193,606		
Made into coke at mines	157,568	154,461		
Shipped to Washington points	843,127	1,088,400		
	1,238,700	1,510,782	30.9	37.0
Shipped to other States:				
California	50,000	18,000		
Idaho	45,000	6,540		
Oregon	345,000	161,486		
	440,000	186,026	10.9	4.6
Delivered to railroads by all-rail routes	2,002,615	1,871,084	50.0	45.8
Exported by rail	15,000	20,000	.4	.5
Shipped to tidewater	313,587	494,320	7.8	12.1
	4,009,902	4,082,212	100.0	100.0

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EXPORTS AND IMPORTS.

Exports of bituminous coal in 1918 were 22,350,730 net tons, compared with 23,839,558 tons in 1917 and 21,254,627 tons in 1916. Exports to Europe were but 48,563 tons, almost a negligible quantity compared with 996,957 tons in 1917 and more than 2,500,000 tons in 1916. This decrease in exports of coal to Europe was due to no lack of demand but to the necessity for the conservation of shipping for strictly war purposes.

Exports of bituminous coal to Canada amounted to 18,134,328 net tons, approximately the same as in 1917. Exports to South America declined slightly, from 1,605,781 net tons in 1917 to 1,465,439 tons in 1918. The statistics of exports and imports in the accompanying table are taken from the records of the Bureau of Foreign and Domestic Commerce of the Department of Commerce.

Coal exported from the United States, in 1916–1918, by countries, in net tons.

Country.	Bituminous.			Anthracite.		
	1916	1917	1918	1916	1917	1918
Europe:						
Azores and Madeira Islands	16,334	2,209	.....	.....	.....	.....
Belgium	.....	.....	.....	.....	28	.....
Denmark	.....	11	.....	36	.....	.....
France	100,249	51,172	8,098	.....	150	1,853
Gibraltar	.....	.....	896	.....	.....	.....
Greece	65,495	3,741	3,241	1,352	.....	.....
Iceland and Faroe Islands	4,849	.....	.....	20	.....	.....
Italy	1,943,281	627,903	11,103	12,119	399	291
Malta, Gozo, etc	.....	.....	.....	271	.....	.....
Netherlands	.....	.....	18,493	.....	.....	.....
Norway	86,750	24,497	.....	113	6	.....
Portugal	19,425	49,428	5,421	.....	291	.....
Russia in Europe	6,376	.....	.....	.....	.....	.....
Serbia, Montenegro, etc	50,723	.....	.....	.....	.....	.....
Spain	151,988	176,406	.....	4	.....	.....
Sweden	79,504	.....	.....	.....	.....	.....
Switzerland	.....	4,546	.....	.....	42	.....
United Kingdom:						
England	3,258	56,984	1,221	56	829	246
Ireland	352	.....		.....	782	.....
	2,528,584	996,957	48,563	13,971	2,527	2,390
North America:						
Bermuda	38,265	44,526	23,499	3,161	1,956	1,631
British Honduras	1,073	1,346	77	90	45	.....
Canada	13,260,180	18,117,377	18,134,328	4,556,375	5,915,074	4,904,678
Costa Rica	25,729	4,781	1,753	84	78	1
Guatemala	14,310	1,158	259	8	7	.....
Honduras	14,286	12,488	7,993	1	.....	.....
Nicaragua	2,867	3,249	2,812	11	.....	75
Panama	479,060	693,237	564,624	858	101	297
Salvador	2	2	4	14	3	3
Greenland	784	787	.....	.....	.....	.....
Mexico	220,133	209,870	182,147	1,652	2,326	5,272
Miquelon, etc	.....	.....	.....	598	225	.....
Newfoundland and Labrador	15,042	3,919	2,174	24,733	11,599	7,426
West Indies:						
Barbados	107,405	62,604	81,240	525	325	153
Jamaica	64,570	79,866	25,400	115	22	.....
Trinidad and Tobago	53,824	26,809	24,917	375	498	.....
Other British West Indies	85,454	83,932	33,823	671	386	232
Cuba	1,438,263	1,579,865	1,613,312	43,314	43,355	43,633
Danish	30,800	37,986	24,169	.....	37	.....
Dominican Republic	22,262	19,142	33,774	8,302	13,148	1,220
Dutch	40,148	49,068	18,757	4	.....	.....
French	91,916	89,252	41,951	11	3	.....
Haiti	4	2,491	1,011	395	327	.....
	16,006,377	21,123,755	20,818,014	4,641,297	5,989,515	4,964,642

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Coal exported from the United States in 1916–1918, by countries, in net tons.—Contd.

Country.	Bituminous.			Anthracite.		
	1916	1917	1918	1916	1917	1918
South America:						
Argentina	1,082,605	355,671	200,367	1,713	10,718	56
Bolivia				340	112	
Brazil	875,945	767,359	626,191	1,292	1,104	540
Chile	295,017	354,340	336,069	578	1,789	139
Colombia	9,629	13,250	1,097	1,674	21	40
Ecuador	25,264	17,833	2,398		28	
Falkland Islands	1,966	5,424	9,975			
Guiana:						
British	11,224	2,129	5,333		6	
Dutch	4,395	3,116	898			
French			11			
Peru	45,824	18,304	24,249	259	222	
Uruguay	171,060	67,411	256,434		224	
Venezuela	3,430	944	2,417	2,195	993	
	2,476,359	1,605,781	1,465,439	8,051	15,217	775
Asia:						
Dutch East Indies	17,846					
Russia in Asia	1					
	17,847					
Oceania:						
Australia	307					
Other British Oceania	1	113	3		1	
Philippine Islands	43	73	38			
	351	186	41		1	
Africa:						
British Africa:						
West	11	2,150	2,334		43	
South				1,495		
East	1,247					
Canary Islands	6,892	1,412	7,315	716		
Egypt	101,608					
French Africa	114,205	95,258	2,407			
Morocco	1,146					
Portuguese Africa		14,059	6,617		3	
	225,109	112,879	18,673	2,211	46	
Grand total	21,254,627	23,839,558	22,350,730	4,665,530	6,007,306	4,967,808
Recapitulation:						
Europe	2,528,584	996,957	48,563	13,971	2,527	2,390
North America	16,006,377	21,123,755	20,818,014	4,641,297	5,989,515	4,964,643
South America	2,476,359	1,605,781	1,465,439	8,051	15,217	775
Asia	17,847					
Oceania	351	186	41		1	
Africa	225,109	112,879	18,673	2,211	46	
Grand total	21,254,627	23,839,558	22,350,730	4,665,530	6,007,306	4,967,808

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Bituminous coal exported from the United States, 1916–1918, by customs districts and ports, in net tons.

Customs district.	Ocean port or rail gateway.	1916	1917	1918
North Atlantic:				
Massachusetts	Boston	478	272	1,668
New York	New York	47,872	16,070	54,568
Philadelphia	Philadelphia	993,833	560,358	56,164
Maryland	Baltimore	980,864	280,197	120,016
Virginia	Hampton Roads	5,695,868	4,659,009	3,619,673
		7,718,415	5,515,906	3,852,084
South Atlantic:				
North Carolina		9,930		
South Carolina	Charleston	64,390	12,537	16,214
Georgia	Savannah	688	6,502	25,640
Florida	Pensacola	7,213	23,173	42,800
Mobile	Mobile	10,940	17,054	7,848
New Orleans	New Orleans	17,713	22,169	73,207
Galveston			41	5,608
Sabine			2	
		110,874	81,478	171,407
Mexican border:				
Arizona		62,502	60,464	98,593
Eagle Pass		12,114		
El Paso		61,716	69,761	55,712
Laredo		42,427		
San Antonio			33,570	14,702
		178,759	163,795	169,007
Pacific coast:				
Washington [a]		12,484	21,477	36,865
San Francisco		244	193	6
Southern California		690	227	101
		13,418	21,897	36,972
Lake Erie ports: Ohio [b]	Lower Lake docks	6,756,221	7,459,894	8,133,063
Rail gateways on Canadian border:				
Eastern:				
Maine and New Hampshire		477	203	80
Vermont		44,709	282,849	140,808
Buffalo		2,770,653	3,273,216	4,022,220
Michigan		923,709	1,920,644	2,058,420
Rochester [c]		1,466,939	1,596,000	1,205,651
St. Lawrence		1,137,795	3,031,028	2,508,505
		6,344,282	10,103,940	9,935,680
Western:				
Duluth and Superior-International Falls ("Soo")		77,521	93,029	29,587
Dakota		54,280	398,761	22,909
Montana and Idaho		53	512	47
		131,854	492,302	52,443
Miscellaneous:				
Hawaii		1	113	3
Porto Rico		575	114	
Alaska		228	119	62
		804	346	65
Grand total		21,254,627	23,839,558	22,350,730

[a] Both rail to Canada and tidewater ports.
[b] Lower Lake docks as follows: Toledo, Sandusky, Huron, Lorain, Cleveland, Fairport, Ashtabula, Conneaut, and Erie.
[c] Both rail-car ferry and Lake Ontario.

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Pennsylvania anthracite exported from the United States, 1916–1918, by customs districts and ports, in net tons.

Customs district.	Ocean port or rail gateway.	1916	1917	1918
North Atlantic:				
Massachusetts	Boston	2,065	3,632	205
New York	New York	228,846	151,234	91,221
Philadelphia	Philadelphia	70,030	43,132	41,695
Maryland	Baltimore	1,590	426	448
Virginia	Hampton Roads	395	8,630	284
		302,926	207,054	133,853
South Atlantic:				
South Carolina	Charleston	56		
Georgia	Savannah		224	1,848
Florida	Pensacola	1,145	90	
Mobile	Mobile			
New Orleans	New Orleans	192	188	76
Galveston		10	49	
Sabine				52
		1,403	551	1,976
Mexican border:				
Arizona			40	276
Eagle Pass				
El Paso		640	545	1,211
Laredo		261	588	
San Antonio				3,706
		901	1,173	5,193
Pacific coast:				
Washington [a]		240	268	118
San Francisco		19	29	3
Southern California		57	47	16
		316	344	137
Lake Erie ports: Ohio [b]	Lower Lake ports.	185,688	84,301	39,116
Rail gateways on Canadian border:				
Eastern:				
Maine and New Hampshire		4,179	4,915	10,334
Vermont		14,523	25,427	22,875
Buffalo		2,345,676	3,097,892	2,611,461
Michigan		3,763	1,037	12,963
Rochester [c]		546,564	778,118	681,096
St. Lawrence		1,224,815	1,784,871	1,446,575
		4,139,520	5,692,260	4,785,304
Western:				
Duluth and Superior-International Falls ("Soo")		8,100	5,445	375
Dakota		26,675	16,177	1,853
		34,775	21,622	2,228
Miscellaneous:				
Hawaii			1	
Porto Rico				
Alaska		1		1
		1	1	1
Grand total		4,665,730	6,007,306	4,967,808

[a] Both rail to Canada and tidewater ports.
[b] Lower Lake docks as follows: Toledo, Sandusky, Huron, Lorain, Cleveland, Fairport, Ashtabula, Conneaut, and Erie.
[c] Both rail-car ferry and Lake Ontario.

Coal exported from the United States, 1910–1918, in net tons.

Year.	Anthracite.	Bituminous.	Year.	Anthracite.	Bituminous.
1910	3,384,222	12,078,348	1915	3,965,255	18,776,640
1911	3,980,479	15,544,204	1916	4,665,530	21,254,627
1912	4,131,444	16,195,175	1917	6,007,306	23,839,558
1913	4,652,912	20,145,168	1918	4,967,808	22,350,730
1914	4,289,873	15,458,072			

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Bituminous coal imported into the United States, 1916–1918, by customs districts, in net tons.

Customs district.	1916	1917	1918
Eastern and Gulf coasts:			
Massachusetts	388,821	349,496	181,806
Maryland	493	1,232	6,735
Florida			
Galveston	829	1,534	448
New Orleans	389	448	4,973
New York	7,172	3,310	14,506
Philadelphia		1,400	672
Porto Rico		333	
Virginia		1,182	268
Georgia			757
	397,704	358,935	210,165
Canadian border:			
Buffalo	1,306		
Chicago	1,680	9,520	13,664
Dakota	1,960	1,164	1,630
Duluth-Superior		1,971	96
Maine and New Hampshire	143,801	74,405	224,930
Michigan	46	372	5,070
Montana and Idaho	493,237	348,276	493,725
St. Lawrence			1,623
Vermont	32,384	1,551	320
Washington	217,755	234,386	277,577
	892,069	671,645	1,018,535
Pacific coast:			
Oregon	3,829	127	6,063
San Francisco	240,444	296,211	91,403
Southern California			
Alaska	53,672	56,549	37,986
Hawaii	126,119	64,986	92,921
	424,064	417,873	228,373
Grand total	1,713,837	1,448,453	1,457,073

Bituminous coal imported into the United States in 1918, by uses, in net tons.

	Lake or rail.	Tidewater.	Total.
Commercial:[a]			
California		13,000	13,000
Georgia		757	757
Illinois	13,664		13,664
Louisiana		4,973	4,973
Maryland		6,735	6,735
Michigan	5,070		5,070
Minnesota	96		96
Montana and Idaho	194,376		194,376
New England	10,201	174,308	184,509
New York	1,623	14,506	16,129
North Dakota	1,630		1,630
Oregon		6,063	6,063
Pennsylvania		672	672
Texas		448	448
Virginia		268	268
Washington	115,112	12,790	127,902
	341,772	234,520	576,292
Railway fuel	449,143	198,737	647,880
Bunker		101,994	101,994
	790,915	535,251	1,326,166

[a] Alaska and Hawaii not included.

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CONSUMPTION OF BITUMINOUS COAL AND LIGNITE BY INDUSTRIES, ACCORDING TO SOURCES.

COAL USED BY RAILROADS.

The statistics of the consumption of coal by railroads were collected in 1917 and 1918 in a different form from that used in 1915 and 1916. To increase both the ease of compilation of the data by the railroads and the accuracy of the figures, the origin of the coal delivered for consumption was requested rather than the origin of the coal consumed.

A comparison of the statistics showing the origin of coal used for railroad fuel for the years 1915, 1916, and 1917 will be found in the report on the distribution and consumption of coal for 1917.[1] In the present report a summary of the statistics for 1918 only is included. The tables of the statistics on deliveries and consumption of coal by railroads, by classes of roads, will be found in Part III of the report of the Distribution Division, United States Fuel Administration. The data here given are summarized from those contained in the report of the Fuel Administration, revised and corrected in final form.

Bituminous fuel coal delivered to railroads by producing districts, 1918, in net tons.

Producing district.	Eastern railroads.	Southern railroads.	Western railroads.	Total.
Central Pennsylvania:				
Rail	18,190,635	.....	.....	18,190,635
Tidewater	124,697	.....	.....	124,697
Lake	229,351	.....	.....	229,351
Northern Pennsylvania:				
Rail	2,087,382	.....	.....	2,087,382
Pittsburgh:				
Rail	5,492,943	.....	.....	5,492,943
Lake	35,655	.....	1,763,257	1,798,912
River	139,976	.....	.....	139,976
Greensburg-Westmoreland:				
Rail	6,142,348	.....	.....	6,142,348
Tidewater	549,370	.....	.....	549,370
Connellsville:				
Rail	2,043,219	.....	.....	2,043,219
Tidewater	267,248	.....	.....	267,248
Cumberland and Piedmont:				
Rail	482,767	.....	33	482,800
Somerset and Meyersdale:				
Rail	276,210	.....	.....	276,210
Tidewater	329,399	.....	.....	329,399
Fairmont:				
Rail	6,227,528	137,249	.....	6,364,777
Tidewater	1,420,235	.....	.....	1,420,235
Lake	.....	.....	974,907	974,907
Northern Ohio:				
Rail	6,920,248	.....	18,784	6,939,032
Lake	.....	.....	1,719,332	1,719,332
Southern Ohio:				
Rail	3,826,636	.....	.....	3,826,636
Lake	.....	.....	162	162
Michigan:				
Rail	274,321	.....	.....	274,321
Northeastern Kentucky:				
Rail	6,630	579,346	.....	585,976
Hazard, Ky.:				
Rail	.....	314,940	.....	314,940
Panhandle, W. Va.:				
Rail	94,198	36	.....	94,234
Kenova-Thacker:				
Rail	3,842	2,367,476	.....	2,371,318
Tidewater	95,522	.....	.....	95,522
Kanawha (Chesapeake & Ohio):				
Rail	288,434	2,842,106	.....	3,130,540
Lake	.....	.....	106,432	106,432
Tidewater	145,000	.....	.....	145,000
Kanawha (Kanawha & Michigan):				
Rail	152,827	27,101	.....	179,928
Tidewater	445	.....	.....	445

[1] U. S. Geol. Survey Mineral Resources, 1917, pt. 2, pp. 1251–1252, 1919.

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Bituminous fuel coal delivered to railroads by producing districts, 1918, in net tons—Con.

Producing district.	Eastern railroads.	Southern railroads.	Western railroads.	Total.
Logan:				
Rail		(a)		(a)
New River:				
Rail		980,791		980,791
Tidewater	171,554			171,554
Pocahontas:				
Rail		1,541,063		1,541,063
Tidewater	124,861			124,861
Southwestern Virginia:				
Rail		2,872,154		2,872,154
Tidewater	193,129			193,129
Southeastern Kentucky:				
Rail	28,130	1,560,116		1,588,246
Tennessee and Georgia:				
Rail		3,209,223		3,209,223
Alabama:				
Rail		4,789,168	418,016	5,207,184
Western Kentucky:				
Rail	204,054	3,569,816	402,905	4,176,775
Tidewater			6,912	6,912
Indiana:				
Rail	7,035,708	920,689	948,054	8,904,451
Illinois:				
Rail	7,393,483	4,457,948	20,518,931	32,370,362
Arkansas:				
Rail			772,916	772,916
Iowa:				
Rail	7,949		3,899,674	3,907,623
Kansas:				
Rail			3,243,432	3,243,432
Missouri:				
Rail	202,998		1,854,733	2,057,731
Oklahoma:				
Rail			2,242,989	2,242,989
Tidewater			1,093	1,093
Texas:				
Rail			941,874	941,874
North Dakota:				
Rail			13,606	13,606
Montana:				
Rail			2,103,232	2,103,232
Northern Wyoming:				
Rail			2,079,950	2,079,950
Southern Wyoming:				
Rail			4,420,482	4,420,482
Colorado:				
Rail			3,246,855	3,246,855
New Mexico:				
Rail			1,735,832	1,735,832
Utah:				
Rail			1,132,838	1,132,838
Washington:				
Rail			1,871,064	1,871,064
Oregon:				
Rail			4,728	4,728
Canada:				
Rail	119		449,024	449,143
Tidewater	198,737			198,737
Unknown:				
Rail	361,090	250	78,124	439,464
Tidewater	3,168			3,168
	71,772,046	30,169,472	56,960,191	158,901,709
All rail	67,743,499	30,169,472	52,388,096	150,301,267
All tidewater	3,623,365		8,005	3,631,370
All lake	265,006		4,564,090	4,829,096
All river	139,976			139,976
SUMMARY.				
On hand January 1, 1918	4,055,801	1,009,877	3,814,096	8,879,774
Deliveries for year 1918	71,772,046	30,169,472	56,960,191	158,901,709
Coal confiscated	1,065,960	380,156	291,675	1,737,791
Coal purchased from other roads	1,502,848	461,994	630,547	2,595,389
Total received	78,396,655	32,021,499	61,696,509	172,114,663
Sold to other roads	1,420,095	463,988	1,455,914	3,339,947
Sold to industries, etc	614,446	163,494	97,061	875,001
Total sold	2,034,541	627,432	1,552,975	4,214,948
Net available for consumption	76,362,114	31,394,067	60,143,534	167,899,715
On hand December 31, 1918	4,715,361	1,822,310	7,200,408	13,738,079
Total consumed during 1918	71,646,753	29,571,757	52,943,126	154,161,636

a Included with Kanawha (Chesapeake & Ohio).

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COAL USED BY STEAMSHIPS.

The following statistics of bunker coal supplied to steamships engaged in foreign commerce are derived from the records of the Bureau of Foreign and Domestic Commerce. They do not include bunker coal delivered to the Army or Navy transport service in 1918. It was the policy of the Treasury Department and the Bureau of Foreign and Domestic Commerce, of the Department of Commerce, to consider shipments of goods to France or elsewhere for the use of the Army or Navy as domestic consumption, and not as exports; likewise, the coal used by the vessels under these services was considered as domestic bunker coal.

The statistics of bituminous coal shipped to tidewater and used for coastwise and local bunker purposes and for the Army and Navy transport service will be found in a previous section of this report dealing with the shipments of coal to tidewater.

Bunker coal supplied to steamers engaged in foreign trade at ports of United States, 1916–1918, in net tons.

Customs district.	Principal ports.	1916	1917	1918
North Atlantic:				
Maine and New Hampshire	Portland	33,527	7,831	29,901
Massachusetts	Boston	177,523	144,295	151,630
New York	New York	3,809,112	3,042,417	2,573,511
Philadelphia	Philadelphia	463,292	322,209	276,680
Maryland	Baltimore	547,057	373,679	274,388
Virginia	Hampton Roads	2,197,113	2,203,425	1,813,771
		7,227,624	6,093,856	4,619,880
South Atlantic and Gulf ports:				
North Carolina		39,811	500	538
South Carolina	Charleston	69,832	56,655	33,790
Georgia	Savannah	35,193	28,133	25,728
Florida		112,948	58,225	60,159
Mobile		68,745	54,736	57,440
New Orleans		414,364	413,140	404,721
Texas (including Sabine)		55,256	48,545	[a] 42,153
Porto Rico		61,190	67,255	26,249
		857,339	727,189	650,873
Great Lakes:				
St. Lawrence		10,779	23,429	35,326
Rochester		42,388	46,221	39,637
Buffalo	Buffalo	29,501	31,700	15,231
Ohio	Lake Erie	244,223	281,149	256,602
Michigan		54,271	71,231	73,280
Wisconsin		1,935	3,501	1,989
Chicago	Chicago	17,657	14,669	31,528
Duluth-Superior	Duluth	2,417	2,552	5,022
		403,171	474,452	458,615
Pacific coast:				
Washington	Seattle	38,401	67,627	142,649
Oregon	Portland	6,015	4,603	26,488
San Francisco	San Francisco	193,055	297,748	[b] 267,063
Alaska		364	17	1,344
Hawaii		38,850	43,663	22,404
		276,685	413,658	459,948
Grand total		8,764,819	7,709,155	6,189,316

[a] Includes Galveston, 1918. [b] Includes southern California, 1918.

COAL USED BY INDUSTRIES.

The statistics given in the following table show the quantities of bituminous coal used in 1918 at the coal mines for steam and heat and used in the manufacture of beehive coke, of by-product coke, and of coal gas (in bench retorts), by States in which the coal was consumed. These data are compiled from reports made directly to the Geological Survey by the consumers. The figures for the total coal consumed in each State, exclusive of railroad fuel and bunker coal, are derived from

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the records of the Fuel Administration, which, however, do not furnish sufficient detail to permit a separation of the coal used by electric utilities, for industrial purposes, and for domestic purposes, such as is shown in the report on the distribution and consumption of coal in Mineral Resources for 1917. The reports of the Distribution Division, United States Fuel Administration, particularly Part III, contain the greater part of the detailed data on the consumption and use of bituminous coal collected by the Fuel Administration.

Bituminous coal of domestic origin consumed in the United States in 1918, in net tons.

[Railway fuel and bunker fuel for ocean vessels not included in this table.]

State.	Used at mines for steam and heat.	Used in manufacture of beehive coke.	Used in manufacture of by-product coke.	Used in manufacture of coal gas.	Used for domestic and industrial purposes, including electrical utilities.	Total coal consumed.
Alabama	593,739	2,949,992	3,877,634	80,477	4,473,535	11,975,377
Arizona				(a)	[b] 234,872	234,872
Arkansas	73,920				1,017,162	1,091,082
California				(a)	[b] 830,368	830,368
Colorado	311,009	1,216,154	345,877	120,634	4,418,817	6,422,491
Delaware				(a)	[b] 721,490	721,490
District of Columbia					1,174,774	1,174,774
Florida				(a)	[b] 440,770	440,770
Georgia	6,250	38,280		87,331	2,751,047	2,882,908
Idaho				8,256	639,648	647,904
Illinois	2,381,197		3,199,620	297,605	40,788,349	46,666,771
Indiana	775,276		5,318,900	178,648	16,798,065	23,070,889
Iowa	190,609			80,675	8,184,606	8,455,890
Kansas	200,259			(a)	[b] 3,629,814	3,830,073
Kentucky	678,090	533,346	728,113	14,272	4,525,066	6,473,887
Louisiana				(a)	[b] 1,186,002	1,186,002
Maryland	55,716		696,576	11,697	3,093,956	3,857,945
Michigan	85,206		(a)	733,853	[c] 19,181,328	20,000,387
Minnesota			1,069,775	104,232	5,410,739	6,584,746
Mississippi				19,095	1,101,264	1,120,359
Missouri	162,243		(a)	596,988	[c] 11,168,745	11,927,976
Montana	175,532			14,065	1,910,603	2,100,200
Nebraska				(a)	[b] 3,619,254	3,619,254
Nevada					444,656	444,656
New England			676,866	829,344	19,328,810	20,835,020
New Jersey			994,300	24,072	5,941,131	6,959,503
New Mexico	39,271	1,047,675		(a)	[b] 414,747	1,501,693
New York			1,516,580	726,349	18,224,099	20,467,028
North Carolina	912			50,215	2,541,918	2,593,045
North Dakota	19,943			18,933	1,470,531	1,509,407
Ohio	908,613	223,200	7,775,623	35,902	31,784,153	40,727,491
Oklahoma	207,917	(a)		(a)	[d] 1,900,783	2,108,700
Oregon	5,270			3,928	429,996	439,194
Pennsylvania	3,612,890	34,059,026	6,514,868	213,999	35,492,279	79,893,062
South Carolina				10,230	1,604,128	1,614,358
South Dakota				(a)	[b] 1,162,468	1,162,468
Tennessee	181,901	564,920	166,157	61,897	4,151,691	5,126,566
Texas	45,015			20,318	2,558,320	2,623,653
Utah	94,978	(a)		38,629	[e] 2,551,650	2,685,257
Virginia	107,519	2,042,429		114,672	5,205,127	7,469,747
Washington	193,606	154,460	47,410	98,287	1,410,085	1,903,848
West Virginia	1,159,961	4,516,108	853,684	(a)	[b] 4,547,992	11,077,735
Wisconsin			(a)	305,918	[c] 7,883,853	8,189,771
Wyoming	252,659			(a)	[b] 557,609	810,268
Alaska	1,955				73,651	75,606
Miscellaneous, including smithing coal					306,307	306,307
Combined States		814,707	3,090,738	55,311		
	12,521,446	48,160,297	36,867,721	4,965,832	[f] 283,325,502	385,840,798

[a] Included in quantity shown for States as used for domestic and industrial purposes and in total of combined States.
[b] Includes coal used for manufacture of coal gas.
[c] Includes coal used for manufacture of by-product coke.
[d] Includes coal used for manufacture of coal gas and beehive coke.
[e] Includes coal used for manufacture of beehive coke.
[f] This total, which represents the net quantity used for domestic and industrial purposes, does not include 814,707 tons used in the manufacture of beehive coke, 3,090,738 tons used in the manufacture of by-product coke, and 55,311 tons used in the manufacture of coal gas, but these quantities are included in the detailed figures by States.

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CONSUMPTION OF BITUMINOUS COAL, BY STATES.

The statistics given below showing the sources and quantity of bituminous coal received in each State do not represent consumption but rather quantities delivered and available for consumption. Consumption was greater or less than deliveries by the quantity of coal put into or taken from storage. Statistics collected by the Fuel Administration in 1918 show clearly that the quantity of bituminous coal in storage in the hands of the consumers was much greater at the end of 1918 than at the beginning, although exact figures are not available, because no comprehensive statistics of stocks as of the beginning of 1918 were collected.

The tables showing coal consumed in different States in 1918 are followed by two tables showing the percentages of distribution, by classes of users, of coal shipped from each producing district and received in each consuming State. These percentages are based upon weekly reports made by operators producing 95 per cent of the coal produced in the United States in the period of 27 weeks from August 3, 1918, to February 1, 1919.

Coal consumed in different States in 1918, in net tons.

[Fuel for railroads and steamships not included.]

Alabama.	
Alabama	11,627,695
Illinois	20,719
Tennessee and Georgia	217,244
Virginia, southwestern	12,285
Kentucky, western	97,434
	11,975,377
Arizona.	
Colorado	10,185
New Mexico	224,687
	234,872
Arkansas.	
Alabama	1,512
Arkansas	621,916
Illinois	267,628
Indiana	150
Iowa	2,117
Kansas	2,225
Kentucky, western	106,404
Missouri	6,014
Oklahoma	81,011
Tennessee and Georgia	2,105
	1,091,082
California.	
Colorado	5,335
New Mexico	56,355
Pennsylvania, central	5,525
Utah and southern Wyoming	653,766
Virginia, southwestern	5,135
Washington	18,000
Tidewater	73,252
	817,368
Imports	13,000
	830,368
Colorado.	
Colorado	6,345,806
Montana and northern Wyoming	996
New Mexico	54,210
Utah and southern Wyoming	17,479
Virginia, southwestern	4,000
	6,422,491
Delaware.	
Pennsylvania:	
Central	316,355
Greensburg and Westmoreland	61,800
Connellsville	24,245
Northern	586
Pittsburgh and panhandle of West Virginia	12,350
Somerset and Cumberland-Piedmont	164,645
West Virginia, Fairmont	99,239
Tidewater	42,270
	721,490
District of Columbia.	
Pennsylvania:	
Central	20,000
Somerset and Cumberland-Piedmont	854,973
Virginia, southwestern	20,115
West Virginia:	
Fairmont	31,047
Kanawha and Kenova-Thacker	6,209
New River	222,430
Pocahontas and Tug River	20,000
	1,174,774
Florida.	
Alabama	173,290
Kentucky:	
Northeastern	7,405
Southeastern	54,080
Tennessee and Georgia	17,810
Virginia, southwestern	80,292
Tidewater	107,893
	440,770
Georgia.	
Alabama	556,585
Indiana	550
Kentucky:	
Northeastern	4,680
Southeastern	1,294,245
Tennessee and Georgia	745,906
Virginia, southwestern	277,910
West Virginia, New River	2,275
	2,882,151
Imports	757
	2,882,908

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Coal consumed in different States in 1918, in net tons—Continued.

[Fuel for railroads and steamships not included.]

Idaho.	
Colorado	5,084
Montana and northern Wyoming	20,736
Utah and southern Wyoming	543,544
Washington	6,540
Lake docks	2,000
	577,904
Imports	70,000
	647,904

Illinois.	
Arkansas	29,810
Illinois	37,427,705
Indiana	6,015,607
Iowa	1,703
Kansas	46
Kentucky:	
Northeastern	241,407
Southeastern	353,095
Western	105,638
Hazard	40,596
Ohio:	
Northern	9,450
Southern	26,272
Oklahoma	750
Pennsylvania:	
Central	38,068
Connellsville	3,944
Pittsburgh and panhandle of West Virginia	2,955
Somerset and Cumberland-Piedmont	10,541
Virginia, southwestern	10,308
West Virginia:	
Fairmont	2,915
Kanawha and Kenova-Thacker	392,301
New River	10,895
Pocahontas and Tug River	969,081
Lake docks	960,000
	46,653,107
Imports	13,664
	46,666,771

Indiana.	
Illinois	2,410,432
Indiana	13,003,787
Kentucky:	
Hazard	264,700
Northeastern	1,172,668
Southeastern	575,861
Western	266,484
Ohio:	
Northern	113,751
Southern	146,771
Pennsylvania:	
Central	44,708
Connellsville	5,249
Pittsburgh and panhandle of West Virginia	205,620
Somerset and Cumberland-Piedmont	8,505
Tennessee and Georgia	4,225
Virginia, southwestern	97,786
West Virginia:	
Fairmont	28,836
Kanawha and Kenova-Thacker	1,176,905
New River	136,360
Pocahontas and Tug River	2,907,241
Lake docks	501,000
	23,070,889

Iowa.	
Arkansas	26,044
Colorado	135,151
Illionois	3,597,048
Indiana	89,796
Iowa	3,819,427
Kansas	79,660
Kentucky:	
Northeastern	40,300
Southeastern	12,610
Western	15,046

Iowa—Continued.	
Missouri	93,216
Montana and northern Wyoming	226,013
Oklahoma	10,983
Utah and southern Wyoming	46,623
West Virginia, Kanawha and Kenova-Thacker	28,974
Lake docks	225,000
	8,455,890

Kansas.	
Arkansas	138,705
Colorado	783,383
Illinois	46,767
Indiana	96
Iowa	14,265
Kansas	2,341,854
Kentucky, western	3,145
Missouri	309,403
Montana and northern Wyoming	1,332
New Mexico	78,390
Oklahoma	98,004
Utah and southern Wyoming	14,729
	3,830,073

Kentucky.	
Illinois	14,306
Indiana	104,784
Kentucky:	
Hazard	292,085
Northeastern	1,140,472
Southeastern	1,411,185
Western	2,909,728
Tennessee and Georgia	12,675
Virginia, southwestern	10,010
West Virginia:	
Kanawha and Kenova-Thacker	618,127
New River	22,380
Pocahontas and Tug River	37,635
	6,473,887

Louisiana.	
Alabama	360,700
Arkansas	27,804
Illinois	86,112
Indiana	23,232
Iowa	138
Kansas	79
Kentucky, western	676,134
Oklahoma	3,865
Tennessee and Georgia	2,120
Virginia, southwestern	845
	1,181,029
Imports	4,973
	1,186,002

Maryland.	
Pennsylvania:	
Central	21,798
Greensburg and Westmoreland	35,296
Connellsville	132,795
Northern	586
Pittsburgh and panhandle of West Virginia	7,110
Somerset and Cumberland-Piedmont	1,487,952
West Virginia:	
Fairmont	489,893
Pocahontas and Tug River	27,060
Tidewater	1,648,721
	3,851,210
Imports	6,735
	3,857,945

Michigan.	
Illinois	963,572
Indiana	1,739,424
Kentucky:	
Hazard	250,190
Northeastern	803,819
Southeastern	744,475
Western	46
Michigan	1,190,497

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Coal consumed in different States in 1918, in net tons—Continued.

[Fuel for railroads and steamships not included.]

Michigan—Continued.	
Ohio:	
Northern	1,618,163
Southern	2,511,074
Pennsylvania:	
Central	23,877
Connellsville	23,406
Greensburg and Westmoreland	10,465
Northern	5,738
Pittsburgh and panhandle of West Virginia	375,259
Somerset and Cumberland-Piedmont	15,408
Tennessee and Georgia	11,635
Virginia, southwestern	52,177
West Virginia:	
Fairmont	198,445
Kanawha and Kenova-Thacker	4,903,432
New River	64,026
Pocahontas and Tug River	467,046
Lake docks	3,843,143
	19,995,317
Imports	5,070
	20,000,387
Minnesota.	
Illinois	1,967,926
Indiana	27,792
Iowa	5,318
Kentucky, western	92
Montana and northern Wyoming	14,532
North Dakota	4,364
Lake docks	4,564,626
	6,584,650
Imports	96
	6,584,746
Mississippi.	
Alabama	341,575
Illinois	22,964
Indiana	96
Kentucky, western	755,734
	1,120,369
Missouri.	
Arkansas	251,153
Colorado	5,612
Kansas	997,260
Kentucky:	
Northeastern	448,680
Southeastern	6,110
Western	62,598
Illinois	6,830,419
Indiana	1,903
Iowa	271,239
Missouri	2,881,900
Montana and northern Wyoming	13,536
Oklahoma	93,990
Pennsylvania:	
Central	3,209
Somerset and Cumberland-Piedmont	7,685
Utah and southern Wyoming	1,690
West Virginia, Pocahontas and Tug River	50,992
	11,927,976
Montana.	
Montana and northern Wyoming	1,695,717
Utah and southern Wyoming	274,107
Lake docks	6,000
	1,975,824
Imports	124,376
	2,100,200
Nebraska.	
Arkansas	126,085
Colorado	1,133,342
Illinois	185,946
Indiana	1,932
Iowa	163,073
Kansas	748,126
Missouri	291,374
Montana and northern Wyoming	590,095
Oklahoma	31,069
Texas	129
Utah and southern Wyoming	344,083
Lake docks	4,000
	3,619,254
Nevada.	
Utah and southern Wyoming	444,656
New England.	
Kentucky, Hazard	150
Pennsylvania:	
Central	[a] 6,801,338
Connellsville	356,655
Greensburg and Westmoreland	290,793
Pittsburgh and panhandle of West Virginia	423,670
Northern	316,350
Somerset and Cumberland-Piedmont	109,005
West Virginia, Fairmont	93,995
Tidewater	12,253,555
	20,650,511
Imports	184,509
	20,835,020
New Jersey.	
Kentucky, Hazard	1,222
Pennsylvania:	
Central	2,051,765
Connellsville	382,850
Greensburg and Westmoreland	479,150
Northern	396,520
Pittsburgh and panhandle of West Virginia	1,054,365
Somerset and Cumberland-Piedmont	852,280
West Virginia:	
Fairmont	849,600
Kanawha and Kenova-Thacker	65,975
Tidewater	826,776
	6,969,503
New Mexico.	
Colorado	82,829
New Mexico	1,403,715
Oklahoma	15,149
	1,501,693
New York.	
Kentucky, Hazard	3,373
Ohio, northern	373,740
Pennsylvania:	
Central	5,701,657
Connellsville	607,880
Greensburg and Westmoreland	442,750
Northern	1,498,200
Pittsburgh and panhandle of West Virginia	3,279,315
Somerset and Cumberland-Piedmont	137,410
West Virginia, Fairmont	423,914
Lake docks	65,000
Tidewater	7,917,660
	20,450,899
Imports	16,129
	20,467,028

[a] Includes 229,351 tons railroad fuel via Lake Ontario.

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Coal consumed in different States in 1918, in net tons—Continued.

[Fuel for railroads and steamships not included.]

North Carolina.

Kentucky:	
Northeastern	13,715
Southeastern	144,885
Tennessee and Georgia	259,016
Virginia, southwestern	899,339
West Virginia:	
Kanawha and Kenova-Thacker	377,715
New River	478,150
Pocahontas and Tug River	420,225
	2,593,045

North Dakota.

Illinois	7,820
Indiana	240
Montana and northern Wyoming	154,060
North Dakota	691,637
Lake docks	654,000
	1,507,777
Imports	1,630
	1,509,407

Ohio.

Illinois	16,000
Indiana	39,664
Kentucky:	
Hazard	824,277
Northeastern	1,655,285
Southeastern	804,912
Western	22,616
Ohio:	
Northern	12,198,428
Southern	5,531,946
Pennsylvania:	
Central	105,750
Connellsville	2,373,121
Greensburg and Westmoreland	681,622
Northern	325,748
Pittsburgh and panhandle of West Virginia	6,916,510
Somerset and Cumberland-Piedmont	162,879
Tennessee and Georgia	5,005
Virginia, southwestern	48,566
West Virginia:	
Fairmont	208,402
Kanawha and Kenova-Thacker	7,016,193
New River	160,960
Pocahontas and Tug River	1,562,924
Lake docks	66,683
	40,727,491

Oklahoma.

Arkansas	73,529
Colorado	145,139
Iowa	1,254
Kansas	145,078
Missouri	24,604
New Mexico	31,330
Oklahoma	1,681,134
Texas	6,632
	2,108,700

Oregon.

Montana and northern Wyoming	1,404
Utah and southern Wyoming	267,241
Washington	161,486
Lake docks	3,000
	433,131
Imports	6,063
	439,194

Pennsylvania.

Kentucky:	
Northeastern	20,641
Southeastern	349
Ohio, northern	67,082
Pennsylvania:	
Central	12,282,131
Connellsville	28,277,368
Greensburg and Westmoreland	7,230,274

Pennsylvania—Continued.

Pennsylvania—Continued.	
Northern	2,551,062
Pittsburgh and panhandle of West Virginia	21,334,122
Somerset and Cumberland-Piedmont	3,128,296
West Virginia:	
Fairmont	3,312,358
Kanawha and Kenova-Thacker	321,690
New River	138
Pocahontas and Tug River	261
Tidewater	1,366,686
	79,892,390
Imports	672
	79,893,062

South Carolina.

Kentucky:	
Northeastern	17,428
Southeastern	293,800
Tennessee and Georgia	135,200
Virginia, southwestern	754,291
West Virginia:	
Kanawha and Kenova-Thacker	66,557
New River	215,455
Pocahontas	113,730
Tidewater	17,895
	1,614,358

South Dakota.

Colorado	30,100
Illinois	228,160
Indiana	576
Iowa	15,948
Kansas	1,271
Missouri	3,488
Montana and northern Wyoming	250,800
North Dakota	10,126
Utah and southern Wyoming	11,999
Lake docks	610,000
	1,162,468

Tennessee.

Alabama	94,575
Arkansas	11,266
Illinois	210,128
Indiana	2,264
Kentucky:	
Southeastern	540,215
Western	1,679,058
Tennessee and Georgia	2,274,379
Virginia, southwestern	314,661
	5,126,566

Texas.

Alabama	35,280
Arkansas	148,141
Colorado	399,132
Illinois	222
Iowa	90
Kansas	2,916
Kentucky:	
Southeastern	6,185
Western	19,498
New Mexico	284,489
Oklahoma	554,503
Texas	1,222,669
	2,623,205
Imports	448
	2,623,653

Utah.

Colorado	995
Utah and southern Wyoming	2,684,262
	2,685,257

Virginia.

Kentucky, southeastern	6,045
Pennsylvania, Somerset and Cumberland-Piedmont	41,145
Virginia, southwestern	2,963,885

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Coal consumed in different States in 1918, in net tons—Continued.

[Fuel for railroads and steamships not included.]

Virginia—Continued.	
West Virginia:	
Fairmont	36,270
Kanawha and Kenova-Thacker	713,130
New River	1,294,323
Pocahontas and Tug River	2,071,687
Tidewater	342,994
	7,469,479
Imports	268
	7,469,747

Washington.	
Montana and northern Wyoming	105,264
Utah and southern Wyoming	156,900
Washington	1,510,782
Lake docks	3,000
	1,775,946
Imports	127,902
	1,903,848

West Virginia.	
Ohio:	
Northern	38,332
Southern	122,446
Pennsylvania:	
Connellsville	238,860
Northern	7,215
Pittsburgh and panhandle of West Virginia	1,813,573
Somerset and Cumberland-Piedmont	212,420
Virginia, southwestern	45,240

West Virginia—Continued.	
West Virginia:	
Fairmont	2,727,356
Kanawha and Kenova-Thacker	1,494,074
New River	1,122,050
Pocahontas and Tug River	3,256,169
	11,077,735

Wisconsin.	
Illinois	2,486,254
Indiana	617,184
Kentucky:	
Hazard	515
Northeastern	7,313
Southeastern	280
Western	26,304
Ohio:	
Northern	20,697
Southern	10,171
Pennsylvania:	
Central	1,306
Pittsburgh and panhandle of West Virginia	1,728
Somerset and Cumberland-Piedmont	1,518
Virginia, southwestern	54
West Virginia:	
Fairmont	4,736
Kanawha and Kenova-Thacker	110,423
New River	25,786
Pocahontas and Tug River	5,538
Lake docks	4,869,964
	8,189,771

Wyoming.	
Colorado	54,266
Montana and northern Wyoming	338,394
Utah and southern Wyoming	417,608
	810,268

DISTRIBUTION OF BITUMINOUS COAL, BY CLASSES OF CONSIGNEES.

The foregoing statistics give the distribution of bituminous coal geographically. From August 3, 1918, to February 1, 1919, the United States Fuel Administration maintained records of shipments from each producing field to certain classes of consumers, representing the order of preference to which coal was supplied under the war program of the Fuel Administration. These statistics will be found in complete detail in Part III of the report of the Distribution Division of the Fuel Administration. As a matter of reference, in connection with the statistics of geographic distribution by States contained in the preceding tables in this report, the two following tables are presented, giving the distribution by classes of consignees. The first table shows the percentages of coal consigned to each State, by classes of consumers. The second table shows the percentage of coal from each producing field consigned to each class of consumers in all the States to which that field made shipment. In the detailed statistics given in the report of the Fuel Administration will be found the data showing percentages of shipment from each field to each class of consumers in each State.

It should be noted that the first class of consumers mentioned, the United States Government, received in all probability a larger percentage of total shipments in 1918 than might be considered normal, owing, of course, to the war activities. The percentages to State and county institutions are probably not far from normal, but the percentages to public utilities and to retail coal dealers are lower than they would be if an entire calendar year were represented in the figures.

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Distribution of all-rail shipments of bituminous coal from Aug. 3, 1918, to Feb. 1, 1919, by consuming States and classes of consignees.

Consuming State.	Percentages of shipments to classes of consignees.				
	United States Government institutions.	State and county institutions.	Public utilities, gas, and electricity.	Retail coal dealers.	Industries, including iron and steel.
New England	2.4	2.8	16.0	18.9	59.9
Middle Atlantic States:					
Pennsylvania	1.2	.9	10.2	6.3	81.4
New York	1.1	1.8	13.3	12.5	71.3
New Jersey	5.4	1.1	15.1	6.6	71.8
South Atlantic and Southern States:					
Alabama	1.1	.3	3.8	6.4	88.4
Arkansas	3.8	1.5	14.4	31.9	48.4
Delaware	1.2	1.6	20.0	9.2	68.0
Maryland and District of Columbia	23.1	2.1	10.3	23.9	40.6
Florida	5.4	2.3	26.2	19.3	46.8
Georgia	4.0	1.1	14.4	30.2	50.3
Kentucky	2.3	1.4	10.0	46.4	39.9
Louisiana	7.0	2.3	29.3	31.0	30.4
Mississippi	1.8	3.2	19.2	33.3	42.5
North Carolina	2.5	.9	12.8	29.7	54.1
South Carolina	14.9	.3	9.5	22.0	53.3
Oklahoma	1.4	.7	5.3	43.9	48.7
Tennessee	.4	1.3	12.6	34.4	51.3
Texas	2.6	1.4	14.7	31.3	50.0
Virginia	9.8	.4	11.2	25.4	53.2
West Virginia	7.6	.3	15.4	13.6	63.1
North Central States:					
Illinois	1.4	1.4	14.6	35.5	47.1
Indiana	.3	1.4	12.9	22.8	62.6
Iowa	1.9	2.6	9.9	50.9	34.7
Kansas	4.2	2.5	8.7	36.0	48.6
Michigan	1.1	1.1	14.8	33.3	49.7
Minnesota	.4	2.1	11.4	46.6	39.5
Missouri	.5	1.9	15.4	34.5	47.7
Nebraska	.6	2.2	5.3	58.7	33.2
North Dakota	1.0	.6	9.3	86.0	3.1
Ohio	.5	.9	11.2	18.9	68.5
South Dakota	1.2	2.2	5.1	79.3	12.2
Wisconsin	.3	2.0	13.9	29.6	54.2
Western States:					
California	2.9	.4	3.9	48.9	43.9
Colorado	.6	.8	12.1	36.7	49.8
Idaho	.6	.7	1.5	72.7	24.5
Montana	.8	1.5	4.1	56.8	36.8
Oregon	2.1	1.1	1.6	91.0	4.2
Washington	3.8	2.7	15.8	66.5	11.3
Wyoming	1.1	.6	11.1	74.1	13.1
Arizona	3.8	.1	.7	34.0	61.4
Nevada	.4	.2	.4	11.9	87.1
New Mexico	4.4	.5	8.2	42.5	44.4
Utah	.1	.7	3.1	40.9	55.2

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Distribution of shipments of bituminous coal from Aug. 3, 1918, to Feb. 1, 1919, by producing fields and classes of consignees.

Producing field.	Percentages of shipments to classes of consignees.							
	Railroad fuel.	Lake.	Tidewater.	United States Government institutions.	State and county institutions.	Public utilities, gas, and electricity.	Retail coal dealers.	Industries, including iron and steel.
Central Pennsylvania	29.5	0.5	18.8	1.6	1.0	9.1	6.6	32.9
Northern Pennsylvania	45.7	2.9	.5	2.2	1.3	3.8	3.4	40.2
Westmoreland, Greensburg, Latrobe, and Ligonier	46.7	4.1	9.5	.5	.3	5.7	1.7	31.5
Fairmont	31.9	8.5	23.4	.5	.2	4.9	.9	29.7
New River	4.8	3.0	76.8	1.8	.....	2.6	4.7	6.3
Pocahontas	6.0	9.0	44.8	1.2	.1	.2	3.2	35.5
Southwestern Virginia and Clinch Valley	35.6	.....	5.9	2.9	.....	11.6	11.7	32.3
Somerset and Cumberland-Piedmont	8.5	.....	41.0	4.0	.7	5.5	7.2	33.1
Alabama	27.5	.....	5.2	1.1	.3	3.8	6.0	56.1
Tennessee and Georgia	43.7	.....	.....	1.5	.7	3.7	16.2	34.2
Connellsville	10.0	2.7	5.1	.1	.1	1.6	1.2	79.2
Pittsburgh, Pa., and panhandle of West Virginia	13.1	23.2	.7	.4	.3	7.7	4.0	50.6
Northern Ohio	26.9	27.3	.....	.1	.3	7.3	10.4	27.7
Southern Ohio	24.0	27.0	.....	1.3	1.6	6.1	20.9	19.1
Michigan	19.3	.....	.....	.6	.9	5.1	31.0	43.1
Northeastern Kentucky	6.5	13.5	.....	.1	.5	14.7	13.4	51.3
Hazard, Ky	13.7	13.1	.....	.6	.5	6.7	38.4	27.0
Southeastern Kentucky	17.9	4.0	1.3	.5	.2	10.4	23.9	41.8
Kanawha and Kenova-Thacker	16.1	23.3	5.0	1.5	.4	8.1	12.2	33.4
Lakes Superior and Michigan	28.5	.....	.....	.4	.6	7.7	25.1	37.7
Western Kentucky	35.2	.....	.....	1.3	1.3	12.4	25.4	24.4
Indiana	31.4	.....	.....	.8	1.2	11.0	20.6	35.0
Illinois	36.2	.....	.....	.6	1.2	8.0	27.4	26.6
Arkansas	34.8	.....	.....	3.2	.7	8.6	12.7	40.0
Iowa	53.5	.....	.....	2.4	2.4	6.5	6.1	29.1
Kansas	32.7	.....	.....	1.2	1.5	7.9	8.5	48.2
Missouri	38.7	.....	.....	2.1	.4	7.7	14.0	37.1
Oklahoma	45.8	.....	.....	.9	.5	4.3	15.2	33.3
Texas	38.5	.....	.....	2.5	1.0	12.7	4.6	40.7
Colorado	23.5	....	.....	.3	.8	6.9	40.1	28.4
New Mexico	55.4	....	.....	1.6	.3	4.3	19.5	18.9
Northern Wyoming and Montana	53.3	.....	.....	.6	.6	1.9	31.0	12.6
Southern Wyoming and Utah	48.5	.....	.....	.2	.3	1.6	27.7	21.7
Washington	44.7	....	8.1	2.6	1.5	7.9	30.7	4.5

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PRODUCTION OF BITUMINOUS COAL, BY CHARACTER OF OPENING AND BY BED OR SEAM.

Schedules furnished to the operators of bituminous coal mines by the Geological Survey on which to report their production in the calendar year 1918 made inquiry as to the character of the mine opening—that is, whether shaft, slope, drift, or strip pit—and also the name or number or other local term applied to the coal bed from which the coal was produced.

The mines were classified into five classes in accordance with the output, and the total production of each class in each State is shown in the following table together with the total number of mines in each class and the number of mines operated through shaft, slope, drift, or as open pit. The first class is that of mines producing more than 200,000 tons in 1918; the second, those producing from 100,000 to 200,000 tons; the third, those producing from 50,000 to 100,000 tons; the fourth, those producing from 10,000 to 50,000 tons; and the fifth, those producing less than 10,000 tons.

It will be noted that in the Mississippi Valley, Illinois, Indiana, and western Kentucky in particular, shaft mines predominate, and that in the Appalachian regions drift mines predominate. Slope mines predominate in Oklahoma, Washington, and Wyoming.

Considerable difficulty has been experienced in tabulating the production by name or number of bed. This difficulty doubtless arose from the fact that many operators know none other than a purely local name for the coal bed on which they are operating. In many fields correlations have not been made by officials of either the State survey or the Federal Survey, and there is no proper way by which the operator can correctly determine the name and number of bed on which he is operating. The same bed may be known by different names in the same field, and to have listed the record throughout as it was submitted by the operator would have made more confusion in the final tabulation. M. R. Campbell, of the United States Geological Survey, examined the returns from the operators for Alabama, Arkansas, Routt County, Colo., Illinois, Ohio, and Pennsylvania. He had the assistance of geologists in the Survey who are familiar with the different fields in these States, and ambiguities and duplications were eliminated by them. The reports indicate that in the far West and in some of the Eastern States, as Michigan, and in the South, in Texas, nearly every mine has its own name for the bed on which it is being operated, so that the tabulation of the returns from these States would simply be a list of names, one for each mine, with the production as reported. These tables have not been included in this report because they are not considered to be significant or to be of any value. The data for Indiana were compiled by Mr. Jonas Waffle, secretary of the Indiana Coal Trade Bureau.

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Character of opening at bituminous coal mines in the United States, 1918.

Alabama.

Class.	Production (net tons).	Mines.					
		Total.	Shaft.	Slope.	Drift.	Strip.	Not specified.
1	8,671,854	23	4	14	4	.....	1
2	2,923,182	22	5	13	2	.....	2
3	4,045,565	56	.....	30	21	2	3
4	3,098,327	116	1	41	57	3	14
5	446,014	96	2	14	33	1	46
	19,184,962	313	12	112	117	6	66

Arkansas.

1	279,008	1	1	.....	.....	.....	.....
2	243,145	2	2	.....	.....	.....	.....
3	482,421	7	4	1	1	.....	1
4	991,390	36	18	11	2	.....	5
5	231,405	71	9	19	4	1	38
	2,227,369	117	34	31	7	1	44

Colorado.

1	3,903,704	14	2	4	8	.....	.....
2	4,553,356	32	14	12	5	.....	1
3	1,850,718	27	8	13	3	.....	3
4	1,849,317	70	9	32	25	.....	4
5	250,476	107	6	15	16	.....	70
	12,407,571	250	39	76	57	.....	78

Georgia.

1	.....	.....	.....	.....	.....	.....	.....
2	.....	.....	.....	.....	.....	.....	.....
3	64,996	1	.....	.....	1	.....	.....
4	.....	.....	.....	.....	.....	.....	.....
5	1,720	1	.....	.....	1	.....	.....
	66,716	2	.....	.....	2	.....	.....

Illinois.

1	70,613,379	163	151	.....	1	.....	11
2	11,427,952	78	62	5	.....	3	8
3	4,364,317	59	48	4	1	.....	6
4	2 373,552	92	58	14	7	2	11
5	511,905	299	44	22	8	3	222
	89 291,105	691	363	45	17	8	258

Indiana.

1	16,303,309	49	47	.....	.....	.....	2
2	8,707,158	60	50	2	.....	4	4
3	3,656,515	46	30	2	2	9	3
4	1,646,582	64	46	6	1	5	6
5	365,070	195	34	8	4	4	145
	30,678,634	414	207	18	7	22	160

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Character of opening at bituminous coal mines in the United States, 1918—Continued.

Iowa.

Class.	Production (net tons).	Mines.					
		Total.	Shaft.	Slope.	Drift.	Strip.	Not specified.
1	1,881,356	7	5				2
2	2,126,367	16	16				
3	2,396,060	32	28	3			1
4	1,550,487	56	37	6			13
5	237,925	110	33	10	4	1	62
	8,192,195	221	119	19	4	1	7

Kansas.

1	846,942	4	4				
2	2,350 643	17	17				
3	2 589 397	36	27			9	
4	1,382,444	48	28			10	10
5	392,521	144	37	6			101
	7,561,947	249	113	6		19	111

Western Kentucky.

1	3,119,182	12	10		2		
2	4,281,180	29	21	3	3		2
3	2,257,063	24	19	2	2		1
4	958,385	45	15	11	9		10
5	182,800	52	11	6	12		23
	10,798,610	162	76	22	28		36

Eastern Kentucky.

1	3,467,805	13		2	10		1
2	5,863,544	44		2	36		6
3	5,718,032	78	1	4	65		8
4	4,767,339	201	2	8	152		39
5	997,287	621	2	5	110		504
	20,814,007	957	5	21	373		558

Maryland.

1	441,054	2	1	1			
2	1,325,441	10	1	1	8		
3	1,327,444	19		2	16		1
4	1,269,473	46		1	38		7
5	133,885	54		1	14		39
	4,497,297	131	2	6	76		47

Michigan.

1							
2	663,710	5	5				
3	689,039	9	9				
4	100,633	4	3				1
5	11,436	9	2				7
	1,464,818	27	19				8

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Character of opening at bituminous coal mines in the United States, 1918—Continued.

Missouri.

Class.	Production (net tons).	Mines.					
		Total.	Shaft.	Slope.	Drift.	Strip.	Not specified.
1	784,897	3	3				
2	1,646,025	12	9			3	
3	1,416,329	21	10		5	5	1
4	1,351,440	52	28	2	2	14	6
5	469,039	336	61	18	12	4	241
	5,667,730	424	111	20	19	26	248

Montana.

1	2,515,373	5	2	3			
2	1,411,363	10	1	1	7		1
3	121,276	2			1		1
4	384,217	12		4	6		2
5	100,276	70	1	8	9		52
	4,532,505	99	4	16	23		56

New Mexico.

1	2,661,968	9			9		
2	839,793	7	2	3	2		
3	213,880	3		3			
4	268,179	10		8	2		
5	39,419	15		4	5		6
	4,023,239	44	2	18	18		6

North Carolina.

1							
2							
3							
4							
5	1,420	1	1				
	1,420	1	1				

North Dakota.

1	299,310	1	1				
2							
3							
4	220,938	11	1	5	1		4
5	199,485	154	2	11	11	3	127
	719,733	166	4	16	12	3	131

Ohio.

1	20,017,647	69	27	8	26	5	3
2	11,448,256	78	19	6	45	7	1
3	6,738,989	88	15	12	52	6	3
4	5,945,458	244	30	31	142	8	33
5	1,662,393	864	21	47	216	7	573
	45,812,943	1,343	112	104	481	33	613

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Character of opening at bituminous coal mines in the United States, 1918—Continued

Oklahoma.

Class.	Production (net tons).	Mines.					
		Total.	Shaft.	Slope.	Drift.	Strip.	Not specified.
1							
2	1,643,980	13	7	1			5
3	1,583,112	22	8	6		2	6
4	1,413,602	54	6	36	2	8	2
5	172,753	69	4	26	2	1	36
	4,813,447	158	25	69	4	11	49

Oregon.

1							
2							
3							
4							
5	13,328	3		2			1
	13,328	3		2			1

Pennsylvania.

1	99,486,249	291	125	57	99		10
2	33,905,360	236	31	49	145	2	9
3	21,092,499	289	20	42	212	6	9
4	20,173,442	802	23	83	579	3	114
5	3,893,191	1,264	16	40	394	2	812
	178,550,741	2,882	215	271	1,429	13	954

South Dakota.

1							
2							
3							
4							
5	7,942	12	2	2	2	1	5
	7,942	12	2	2	2	1	5

Tennessee.

1	1,469,251	6		1	5		
2	2,005,945	16		1	14		1
3	1,887,397	27	1	3	20		3
4	1,245,283	56	2	11	33		10
5	223,172	79		2	24		53
	6,831,048	184	3	18	96		67

Texas.

1							
2	819,407	6	2				4
3	669,597	10	6	1			3
4	735,641	25	12	4			9
5	36,490	6		5			1
	2,261,135	47	20	10			17

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Character of opening at bituminous coal mines in the United States, 1918—Continued.

Utah.

Class.	Production (net) tons).	Mines.					
		Total.	Shaft.	Slope.	Drift.	Strip.	Net specified.
1	4,246,781	11	.....	7	4	.....	.....
2	455,628	3	.....	3	.....	.....	.....
3	304,440	4	.....	1	2	.....	1
4	104,893	3	.....	2	.....	.....	1
5	25,083	36	1	4	3	.....	28
	5,136,825	57	1	17	9	.....	30

Virginia.

1	5,426,441	12	1	1	.....	.....	10
2	2,077,010	16	.....	10	6	.....	.....
3	1,435,274	21	.....	3	18	.....	.....
4	1,013,371	45	1	5	28	.....	11
5	337,712	95	.....	8	17	.....	70
	10,289,808	189	2	27	69	.....	91

Washington.

1	1,969,245	7	.....	6	.....	.....	1
2	843,233	6	.....	6	.....	.....	.....
3	604,481	9	.....	8	1	.....	.....
4	626,366	23	.....	9	9	.....	5
5	38,887	10	1	3	2	.....	4
	4,082,212	55	1	32	12	.....	10

West Virginia.

1	26,687,159	99	8	6	81	.....	4
2	27,196,355	197	25	12	154	.....	6
3	20,766,583	296	10	12	248	.....	26
4	13,817,739	515	6	33	417	.....	59
5	1,468,003	638	2	23	184	3	426
	89,935,839	1,745	51	86	1,084	3	521

Wyoming.

1	6,174,728	20	1	14	3	.....	2
2	2,269,277	14	4	10	.....	.....	.....
3	812,549	11	1	8	.....	.....	2
4	164,207	6	1	3	.....	.....	2
5	17,927	31	.....	4	1	.....	26
	9,438,688	82	7	39	4	.....	32

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Bituminous coal produced in 1918, by name or number of bed or seam.

Alabama.

Name or number of bed or seam.	Number of mines.	Production. Net tons.	Production. Percentage of State total.
Altoona	5	128,538	0.67
America	5	283,668	1.48
America and Pratt	3	141,313	.74
Battle Creek	1	15,365	.08
Belmont	1	2,754	.01
Black Shale	1	3,200	.02
Blue Creek	5	424,963	2.22
Blue Creek and Little Jagger	1	73,134	.38
Black Creek	37	1,421,316	7.41
Brookwood	2	38,066	.20
Carter	3	22,209	.12
Coal City, Marion, and Broken Arrow	3	70,832	.37
Clark	1	54,924	.29
Clark and Gholson	4	239,430	1.25
Corona	18	571,677	2.98
Gholson	1	94,848	.49
Gould	1	3,919	.02
Gwinn	1	4,425	.02
Harkness	5	288,726	1.50
Helena	6	364,855	1.90
Jagger	24	1,261,958	6.58
Jefferson	5	364,358	1.90
Mary Lee	67	4,717,973	24.59
Mammoth	2	416,656	2.17
Marion	2	53,426	.28
Maylene	1	30,543	.16
Montevallo	2	152,473	.79
Millidale	6	647,691	3.38
Millidale, Carter, and Brookwood	1	138,481	.72
New Castle	2	311,024	1.62
Nickle Plate	14	567,714	2.96
Pratt	31	4,590,896	23.93
Pratt and Nickle Plate	5	229,522	1.20
Rosa	3	99,023	.52
Straven	1	26,067	.14
Thompson	6	564,921	2.94
Wadsworth	2	4,611	.02
Water Works	1	28,980	.15
Woodstock	4	333,130	1.74
Youngblood	2	243,491	1.27
Yessick	1	7,109	.04
Not specified	27	146,541	.75
	313	19,184,962	.....

Arkansas.

Hartshorne	74	1,781,842	80.00
Hartshorne: Denning	7	226,471	10.17
Hartshorne: Spadra	8	72,219	3.24
Hartshorne: Shinn Basin	2	92,192	4.14
Paris	7	48,357	2.17
Charleston	1	100	(a)
Not specified	18	6,188	.28
	117	2,227,369	.....

Illinois.

No. 1	23	1,010,291	1.13
No. 2	23	2,036,153	2.28
No. 3	16	1,480,595	1.66
No. 4	1	2,827	(a)
No. 5	133	17,087,015	19.14
No. 6	261	63,756,227	71.40
No. 7	27	3,069,466	3.44
No. 9	1	127,271	.1
Nos. 1 and 2	2	358,735	.40
Not specified	204	362,526	.41
	691	89,291,105	.....

a Less than 0.01 per cent.

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Bituminous coal produced in 1918, by name or number of bed or seam—Continued.

Indiana.

[Compiled by the Indiana Coal Trade Bureau. The figures do not include output of wagon mines.]

Name or number of bed or seam.	Number of mines.	Production.	
		Net tons.	Percentage of State total.
Third	.....	1,929,299	6.37
Fourth	.....	9,478,483	31.27
Fifth	.....	15,070,674	49.72
Sixth	.....	2,435,377	8.03
Seventh	.....	261,137	.86
Minshall	.....	384,997	1.27
Block	.....	750,235	2.48
	.....	30,310,102	.....

Iowa.

Appanoose	1	12,811	0.16
Bituminous	3	25,327	.31
Block	2	105,659	1.29
Buxton	1	149,471	1.82
Boone County	1	47,728	.58
Centerville	7	155,279	1.90
No. 5 Deep Vein	1	127,235	1.55
Deep Vein	1	151,453	1.85
Lower Vein	5	382,096	4.66
Lockman Lower	1	76,962	.94
Low Coal	3	100,666	1.23
Monroe	1	96,092	1.17
Mystic or Centerville	1	103,742	1.27
No. 8	1	3,050	.04
Peacock Walnut Block	1	6,631	.08
Thin Vein	1	17,000	.21
Upper and Lower	2	175,339	2.14
First	17	271,147	3.31
Second	10	436,280	5.33
Second and Third	2	303,437	3.70
Third	17	1,157,720	14.13
Third Iowa vein	2	240,647	2.94
Upper vein	1	624	.01
Fifth	4	261,376	3.19
Not specified	135	3,784,423	46.19
	221	8,192,195	.....

Kansas.

Leavenworth	2	99,339	1.31
Lightning Creek	3	106,203	1.41
Osage	4	16,308	.22
Pittsburg Cherokee	76	3,724,528	49.25
Top seam	8	201,138	2.66
Weir Pittsburg	7	1,056,288	13.97
Not specified	149	2,358,143	31.18
	249	7,561,947	.....

Western Kentucky.

Bituminous	2	75,543	0.70
Blue Gem	1	125	(a)
Empire	2	40,470	.37
Flower Hill	1	13,271	.12
No. 6	3	98,139	.91
No. 9	64	5,626,682	52.12
No. 9 Bituminous	1	132,078	1.22
No. 9 West Kentucky	4	557,137	5.16
Nos. 9 and 11	11	1,811,370	16.78
No. 9 Kentucky	1	14,583	.12

[a] Less than 0.01 per cent.

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Bituminous coal produced in 1918, by name or number of bed or seam—Continued.

Western Kentucky—Continued.

Name or number of bed or seam.	Number of mines.	Production.	
		Net tons.	Percentage of State total.
No. 11	18	1,187,560	11.00
No. 11 Kentucky series	1	257,805	2.39
Nos. 11 and 12	1	32,871	.30
No. 12	3	324,582	3.01
No. 14	2	68,357	.63
No. 14 West Kentucky	1	55,004	.51
Not specified	46	503,083	4.66
	162	10,798,610	.....

Eastern Kentucky.

Alma	1	10,524	0.05
Amburgy	2	6,125	.03
Anxier	2	20,215	.10
Barner	2	103,106	.50
Beattyville	1	30,251	.14
Beattyville No. 2	1	700	(a)
Big Sandy	1	12,537	.06
Blue Gem	19	148,203	.72
Bulldog	3	20,321	.10
Creech	1	212,885	1.02
Crescent Jellico	1	21,171	.10
"C"	2	490,467	2.36
Dan Lear	1	10,493	.05
Dean	13	445,264	2.14
Elkhorn	58	3,539,948	17.00
Elkhorn "C" seam	1	540,127	2.59
Elkhorn No. 1	2	67,901	.34
Elkhorn No. 2	3	20,915	.10
Elkhorn No. 3	1	177,470	.85
Elkhorn No. 4	1	56,542	.27
Elkhorn No. 6	1	106,329	.51
Elkhorn or No. 3	2	268,913	1.29
Famous Elkhorn	1	2,005	.01
Freeburn	11	1,520,032	7.30
Harlan	29	1,459,585	7.01
Hause	1	6,388	.03
Harlan and Macon	1	1,325	.01
Hazard No. 4	11	97,931	.47
Horse Creek	1	700	(a)
Jack Rock	2	82,108	.39
Jellico	17	860,069	4.14
Jellico and Blue Gem	1	2,275	.01
Kellioka	3	12,849	.06
Kentucky No. 1	2	65,672	.32
Kentucky No. 5	1	950	(a)
Kentucky No. 7	1	14,735	.07
Laurel	3	31,570	.15
Little Elkhorn	1	13,081	.06
Lower Elkhorn	3	20,960	.10
Lower Hignite	5	214,110	1.03
Lower and Upper Elkhorn	5	442,081	2.13
Marrowbone Nos. 1 and 2	1	130,714	.63
Mason	6	149,994	.72
McHenry	1	23,400	.12
Millard	1	13,420	.06
Millers Creek	5	392,262	1.89
Millers Creek No. 1	1	7,000	.03
Mingo	1	70,152	.34
Moss Jellico	1	61,650	.30
No. 1	19	1,095,674	5.26
No. 2	11	205,887	.99
No. 2 Gas	1	19,984	.10
No. 3	8	220,907	1.06
No. 3 Cannel	1	10,400	.04
No. 4	17	502,756	2.42
No. 4 Rider	3	12,140	.06
Nos. 4 and 5	1	98,086	.47
Nos. 4 and 7	1	154,469	.74

a Less than 0.01 per cent.

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Bituminous coal produced in 1918, by name or number of bed or seam—Continued.

Eastern Kentucky—Continued.

Name or number of bed or seam.	Number of mines.	Production.	
		Net tons.	Percentage of State total.
No. 5	1	20,033	.10
No. 6	8	793,353	3.81
Nos. 6 and 7	1	6,382	.03
No. 7	9	342,649	1.65
Nos. 7 and 8	1	37,690	.18
Pond Creek	9	455,908	2.19
Pond Creek and Freeburn	2	196,303	.94
Poplar Lick	5	153,998	.74
Rinu	4	15,373	.07
Sandstone Parting	3	49,335	.24
Smiths	1	106,601	.51
Sterling	1	101,400	.49
Straight Creek	11	364,465	1.75
Taggart	1	96,765	.46
Terry's Fork	2	28,096	.13
Thacker	5	335,636	1.61
Thacker Alma	1	82,328	.40
Thacker Pond Creek	2	278,153	1.34
Thin Seam	1	2,650	.01
Upper Elkhorn	2	59,019	.28
Wallins	4	337,824	1.62
Warfield	1	165,183	.79
Wenona	4	103,818	.50
Not specified	581	2,353,437	11.30
	957	20,814,007	.....

Maryland.

Bakerstown	5	192,947	4.29
Bakerstown and Freeport	1	59,666	1.33
Bakerstown and Pittsburgh	2	46,251	1.03
Big Vein	5	36,375	.81
Big Vein and Bakerstown	2	203,294	4.52
Big Vein and Tyson	3	214,699	4.77
Bluebaugh	1	49,679	1.10
Clarion	1	15,159	.31
Freeport	1	11,965	.27
Georges Creek Big Vein	1	34,464	.77
Kittanning	6	265,360	5.90
Kittanning and Freeport	2	129,099	2.87
Lower Kittanning	7	485,952	10.81
Parker	1	39,838	.89
Pittsburgh	17	1,144,528	25.45
Pittsburgh Big Vein	3	295,351	6.57
Pittsburgh Tyson	2	99,043	2.20
Pittsburgh, Tyson, and Bakerstown	1	101,529	2.26
Red Stone	1	5,550	.12
Split Six	1	12,560	.28
Tyson	3	94,280	2.08
Tyson Waynesburg	1	163,940	3.65
Upper Freeport	4	92,329	2.05
Upper and Lower Kittanning	3	132,703	2.95
Upper Kittanning and Bakerstown	1	26,835	.60
Upper Sewickley	4	231,327	5.14
Not specified	52	312,574	6.95
	131	4,497,297	.....

Missouri.

Bates County	1	2,674	0.05
Bevier	10	1,286,369	22.70
Bituminous	3	54,492	.96
Cainsville	1	62,757	1.11
Cherokee	7	405,279	7.15
Cherokee Pittsburg	5	410,825	7.25
Foster	1	450	.01
First	1	4,212	.07
Leavenworth	2	71,461	1.26

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Bituminous coal produced in 1918, by name or number of bed or seam—Continued.

Missouri—Continued.

Name or number of bed or seam.	Number of mines.	Production. Net tons.	Production. Percentage of State total.
Lexington	13	654,530	11.55
Mulkey	2	46,875	.83
One	8	108,517	1.91
Second	2	30,789	.54
Three	5	13,961	.25
Third or Fourth Bed	1	168,382	2.97
Sixth	1	145,512	2.57
Pittsburg	3	117,450	2.07
Rich Hill	3	61,118	1.08
Richmond	11	262,140	4.63
Tebo	7	102,205	1.80
Top Seam	1	1,925	.03
Trenton	1	11,643	.21
Trough	1	12,100	.21
Weir City	1	37,498	.66
Not specified	333	1,594,566	28.13
	424	5,667,730	.....

Ohio.

Brookville	40	485,156	1.06
Clarion	1	5,059	.01
Freeport	2	500,557	1.09
Lower Freeport	4	210,318	.46
Lower Kittanning	37	640,543	1.40
Lower Mercer	12	187,550	.41
Lower Kittanning and Brookville	1	19,700	.04
Mercer and Middle Kittanning	1	30,247	.07
Middle Kittanning	269	13,866,024	30.27
Pittsburgh	132	17,688,359	38.61
Pomeroy	34	2,477,914	5.41
Quakertown	19	293,578	.64
Sharon	19	507,664	1.11
Lower and Middle Kittanning	7	389,846	.85
Tionesta	1	18,482	.04
Upper Freeport	62	6,510,231	14.21
Upper Mercer	3	13,023	.03
Upper Freeport and Middle Kittanning	5	309,141	.67
Upper Freeport, Middle Kittanning, Quakertown, and Sharon	1	19,645	.04
Not specified	693	1,639,906	3.58
	1,343	45,812,943	.....

Oklahoma.

Alderson	1	115,410	2.40
Broken Arrow	1	27,434	.57
Colgate Lehigh	1	24,806	.51
Collinsville	1	11,826	.25
Dewar	2	64,138	1.33
Hartshorne	17	868,118	18.08
Henryetta	12	569,450	11.83
Henryetta Dewar	4	91,441	1.90
Lehigh	6	447,567	9.30
Lower Hartshorne	6	208,862	4.34
McAlester	24	624,100	12.97
McCurtain Massey	1	28,893	.60
No. 2	1	14,569	.30
Panama	4	47,925	1.00
Secco	2	4,308	.09
Upper Witteville	1	100,908	2.10
Wilburton	4	144,448	3.00
Not specified	70	1,419,244	29.48
	158	4,813,447	.....

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Bituminous coal produced in 1918, by name or number of bed or seam—Continued.

Pennsylvania.

Name or number of bed or seam.	Number of mines.	Production.	
		Net tons.	Percentage of State total.
Barnett	14	253,291	0.14
Barnett and Kelly	2	99,537	.06
Bear Creek	3	14,632	.01
Berlin	3	135,819	.08
Bloss	10	463,071	.26
Brookville	61	2,729,350	1.53
Brookville or Clarion	3	33,889	.02
Clarion	16	157,679	.09
Freeport	30	2,571,049	1.44
Fulton	13	799,246	.45
Fulton and Barnett	6	154,932	.09
Freeport and Kittanning	2	35,356	.02
Kelly	17	621,079	.35
Kittanning	9	226,946	.13
Lower Freeport	225	12,813,625	7.18
Lower Kittanning B	384	25,114,437	14.06
Lower Kittanning and Lower and Upper Freeport	1	282,633	.16
Lower Freeport and Lower Kittanning	6	194,035	.11
Lower Freeport, Lower Kittanning, and Brookville	2	100,434	.06
Lower Freeport and Middle Kittanning	5	114,244	.06
Lower Freeport, Middle Kittanning, and Lower Kittanning	1	30,045	.02
Lower Kittanning and Brookville	6	156,785	.09
Middle and Lower Kittanning	1	35,972	.02
Middle Kittanning	56	1,920,720	1.08
Middle Kittanning and Upper Freeport	5	167,079	.09
Mercer	2	1,245	(a)
Pittsburgh	606	94,656,136	53.01
Pittsburgh and Upper Freeport	1	51,427	.03
Pittsburgh and Redstone	7	366,115	.21
Platt	1	42,892	.02
Price	2	15,931	.01
Price or Berlin	2	26,752	.01
Redstone	11	353,828	.20
Sewickley	29	1,154,016	.65
Seymour	4	341,682	.19
Upper Freeport	240	15,438,723	8.65
Upper and Lower Freeport	40	4,886,500	2.74
Upper Kittanning	114	6,394,307	3.58
Upper Freeport and Lower Kittannning	2	275,572	.15
Upper Kittanning and Lower Kittanning	6	156,035	.07
Upper Clarion	2	20,656	.01
Upper and Lower Freeport and Middle Kittanning	2	28,489	.02
Upper Freeport, Lower Kittanning, and Brookville	1	26,004	.01
Waynesburg	12	148,368	.08
Not specified	922	4,940,175	2.76
	2,882	178,550,741	.....

Tennessee.

Battle Creek	1	85,587	1.25
Bear Wallow	1	38,032	.56
Blue Gem	6	70,801	1.04
Bon Air	1	31,837	.47
Bon Air No. 2	7	668,440	9.79
Brushy Mountain	3	219,460	3.05
Coal Creek	16	641,314	9.39
Coal Creek, Tennessee seam	2	138,767	2.03
Dean	3	262,634	3.85
Etna	1	20,046	.29
Fork Ridge	1	248,280	3.63
Glen Mary	1	13,010	.19
Jack Rock No. 2	1	20,879	.32
Jellico	8	301,048	4.45
Jordan	1	71,749	1.05
Log Mountain	1	93,745	1.37
Mason and Sterling	1	103,866	1.52
Mingo	2	317,772	4.65
Mingo No. 1 and Sandstone No. 2	2	22,098	.32
Nelson and Sewanee	1	52,751	.77
No. 1	1	24,683	.36

(a) Less than 0.01 per cent.

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Bituminous coal produced in 1918, by name or number of bed or seam—Continued.

Tennessee—Continued.

Name or number of bed or seam.	Number of mines.	Production.	
		Net tons.	Percentage of State total.
No. 4	4	63,613	.93
Nos. 5 and 7	1	65,181	.96
No. 7	2	194,690	2.85
No. 10	1	50,824	.74
Paint Rock	4	41,794	.61
Petros	1	1,033	.02
Pioneer	1	76	(a)
Red Ash	8	236,177	3.46
Rich Mountain	4	143,153	2.10
Sewanee	19	1,189,448	17.41
State	2	44,609	.65
Sterling	2	175,618	2.57
Not specified	79	1,145,033	16.76
	184	6,831,048	.....

Virginia.

Alley	1	20,366	0.20
Banner	2	55,483	.54
Big Seam	1	2,142	.02
Brush Mountain Big Vein	1	3,250	.03
Dorchester	3	372,000	3.62
Edwards	3	126,748	1.23
Haskell	1	12,000	.12
Hog Wallow	1	79,487	.77
Imboden	13	2,349,760	22.84
Jaw Bone	4	24,670	.24
Jewell Pocahontas	1	73,911	.70
Kelley	1	6,275	.06
Kelley and Imboden	1	97,068	.94
Lower Banner	5	128,441	1.25
Mohawk	1	60,400	.59
Middle Norion	1	15,000	.15
Nos. 1 and 2	2	159,414	1.55
Nos. 2 and 4	1	36,050	.35
No. 3	4	1,121,568	10.90
No. 5	9	352,434	3.43
Nos. 5 and 7	1	66,903	.65
No. 6	1	132,797	1.29
No. 1 Black Mountain	1	30,379	.30
No. 3 Black Mountain	1	7,577	.07
No. 6 and Jawbone	1	77,121	.75
North Fork	1	8,000	.08
Parsons	1	218,701	2.13
Price Mountain	2	39,440	.38
Red Ash	4	130,496	1.27
Splash Dam	2	16,444	.16
Taggart	1	674,941	6.56
Town Hill	1	60,173	.59
Upper Banner	18	1,137,227	11.05
Upper and Lower Banner	2	1,658,762	16.12
Upper Banner, Lower Banner, and Widow Kennedy	1	22,600	.22
Virginia Anthracite	2	79,554	.77
Widow Kennedy	4	34,835	.34
Wise No. 1	1	72,384	.70
Not specified	88	724,907	7.04
	189	10,289,808	.....

West Virginia.

Alma	10	417,073	.45
Bakerstown	24	312,512	.35
Bradshaw	2	39,341	.04
Belmont	1	21,427	.02
Beckley	42	4,150,491	4.63
Beckley No. 2	2	10,972	.01

a Less than 0.01 per cent.

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Bituminous coal produced in 1918, by name or number of bed or seam—Continued.

West Virginia—Continued.

Name or number of bed or seam.	Number of mines.	Production.	
		Net tons.	Percentage of State total.
Beckley Fire Creek	1	61,700	.07
Beckley, Pocahontas, No. 3	1	116,878	.13
Beckley & Sewell	3	304,047	.34
Black Band	4	142,484	.16
Campbell Creek No. 2	1	48,276	.05
Cedar Grove	8	891,981	.99
Chilton	22	1,577,647	1.75
Coalburg	34	2,466,532	2.74
Coalburg and Belmont	4	188,608	.21
Coalburg and Cedar Grove	1	29,056	.03
Coalburg and Lewiston	2	6,095	.01
Coalburg Peerless	1	76,028	.08
Coalburg, Winifred, Thacker	1	152,951	.17
Connellsville	1	47,254	.05
Dovothy	1	97,319	.11
Draper	1	46,834	.05
Draper and Dingess	1	50,869	.06
Draper and Eagle	1	63,313	.07
Eagle	28	1,713,178	1.90
Eagle No. 1	5	427,596	.48
Eagle, No. 5, Splint	2	83,500	.09
Eagle, No. 2, Gas	1	33,343	.04
Eagle No. 2	3	231,676	.26
Eagle Island Creek	2	216,132	.24
Eagle Powellton	1	470,122	.52
Eagle, Thacker, Island Creek	3	236,062	.26
East Lynn	1	36,860	.04
Elk Garden-Big Vein	1	29,480	.03
Elk Lick	1	1,800	(a)
Fire Creek	23	914,272	1.02
Freeburn	3	218,274	.24
Freeport	29	957,381	1.06
Freeport-Kittanning	1	28,427	.03
Georges Creek Big Vein	2	91,937	.10
Georges Creek Small Vein	1	11,901	.01
Glen Alum	1	180,522	.20
Iaeger	1	7,969	.01
Island Creek	44	5,198,358	5.78
Island Creek Thacker	2	146,070	.16
Kanawha	3	55,523	.06
Kanawha, No. 1 Gas, No. 2 Gas, Arsted, and Eagle	2	259,973	.29
Kanawha No. 5	4	164,429	.18
Kittanning	27	1,350,168	1.50
Lewiston	6	225,596	.25
Lewiston No. 2 Gas	1	15,150	.02
Little Eagle	1	7,200	.01
Little Pittsburgh	1	3,604	(a)
Lower Freeport	2	83,980	.04
Lower Kittanning	24	1,410,533	1.58
Mahoning	1	1,248	(a)
Mason	1	6,270	.01
Middle Kittanning	3	91,138	.10
Mohawk	1	86,684	.10
Masontown	1	16,690	.02
No. 1	2	4,699	.01
No. 1 Gas	3	197,517	.22
No. 2	15	1,402,538	1.56
No. 2 Gas	53	2,387,471	2.65
No. 2 Gas and Coalburg	1	1,050	(a)
No. 3	3	186,123	.21
Nos. 3 and 4	1	47,719	.06
No. 5	4	384,946	.43
No. 5 Block	23	846,927	.94
No. 5 and Lewiston	4	110,138	.12
No. 5 Splint	4	150,951	.17
No. 7	2	142,554	.16
No. 8	1	13,888	.02
No. 8a	1	30,561	.03
Peerless	4	61,291	.07
Pittsburgh	197	13,509,518	15.02
Pittsburgh No. 8	33	2,607,012	2.90
Pittsburgh and Sewickley	1	44,296	.05
Pittsburgh and Red Stone	1	51,359	.06
Pittsburgh, Red Stone, and Sewickley	1	172,532	.19
Pocahontas	28	1,785,510	1.99

a Less than 0.01 per cent.

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Bituminous coal produced in 1918, by name or number of bed or seam—Continued.

West Virginia—Continued.

Name or number of bed or seam.	Number of mines.	Production.	
		Net tons.	Percentage of State total.
Pocahontas No. 3	62	10,810,422	12.02
Pocahontas Nos. 3 and 4	14	4,945,,352	5.51
Pocahontas Nos. 3 and 6	1	35,880	.04
Pocahontas No. 4	4	281,760	.31
Pocahontas No. 7	1	96,422	.11
Pocahontas No. 12	1	119,157	.13
Pocahontas Sewell	1	30,550	.03
Pomeroy	1	48,962	.05
Pond Creek	2	56,781	.06
Powellton	4	178,244	.21
Queen	1	2,000	(a)
Quinnimont	2	53,037	.06
Raymond	4	129,119	.14
Red Jacket	4	255,492	.29
Red Jacket Thacker	1	138,926	.15
Red Stone	16	616,168	.69
Sewell	92	6,647,680	7.39
Sewell No. 5	1	32,972	.04
Sewickley	22	842,025	.94
Thacker	15	542,716	.60
Upper Freeport	25	1,056,194	1.17
Upper Freeport and Lower Kittanning	3	68,676	.08
Upper Kittanning	2	9,779	.01
Upper and Lower Kittanning	1	21,164	.02
Upper Potomac	8	659,906	.73
Upper Sewickley	1	3,640	(a)
War Creek	12	680,501	.76
War Eagle No. 1	2	75,465	.08
Waynesburg	3	18,398	.02
Welch	5	246,574	.27
Welch and Pocahontas	1	233,233	.26
Westerley No. 1	1	155,715	.17
Winifrede	18	1,212,056	1.35
Winifrede Coalburg	3	303,473	.34
Winifrede, Coalburg, Freeport	1	83,858	.09
Winifrede Pond Creek	2	172,230	.19
Winifrede Thacker	3	149,488	.17
Not specified	621	8,491,480	9.45
	1,745	89,935,839	.....

a Less than 0.01 per cent.

PRODUCTION OF BITUMINOUS COAL, BY SIZE OF MINES.

Reports of production were received by the Geological Survey for 11,038 bituminous coal mines in 1918, compared with 10,634 mines in 1917. The increase occurred principally in mines producing from 10,000 to 50,000 tons, and mainly in Kentucky, Ohio, Pennsylvania, and West Virginia. Statistics showing the production by size of mines for 1917 and 1918 are contained in the following tables. These statistics properly belong in Part A of the report on coal, but were delayed in preparation and are accordingly included in this part.

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Bituminous coal produced in the United States in 1917, according to classes of mines.

State	First class (mines producing more than 200,000 tons).					Second class (mines producing from 100,000 to 200,000 tons).					Third class (mines producing from 50,000 to 100,000 tons).				
	Mines.		Quantity.			Mines.		Quantity.			Mines.		Quantity.		
	Number.	Percentage.	Total (net tons).	Average per mine (net tons).	Percentage.	Number.	Percentage.	Total (net tons).	Average per mine (net tons).	Percentage.	Number.	Percentage.	Total (net tons).	Average per mine (net tons).	Percentage.
Alabama	28	9.7	11,040,920	394,319	55.0	27	9.4	3,458,017	128,075	17.2	43	14.9	3,206,216	74,563	16.0
Arkansas						4	3.5	551,336	137,834	25.7	11	9.7	757,587	68,872	35.3
California, Idaho, and Alaska															
Colorado	16	6.3	4,629,349	289,334	37.1	24	9.5	3,574,623	148,943	28.6	33	13.0	2,417,657	73,262	19.4
Georgia						1	50.0	117,403	117,403	98.6					
Illinois	154	20.2	68,709,245	446,164	79.7	77	10.1	11,654,782	151,031	13.5	45	5.9	3,114,477	69,211	3.6
Indiana	52	12.6	16,708,099	321,310	62.9	41	9.9	6,364,068	155,221	24.0	30	7.3	2,031,943	67,731	7.7
Iowa	6	2.8	2,017,602	336,267	22.5	26	11.9	3,553,759	136,683	39.6	31	14.2	2,077,590	67,019	23.1
Kansas	4	2.2	864,189	216,047	12.1	22	11.8	2,839,657	129,075	39.6	28	15.1	2,105,612	75,200	29.3
Kentucky	20	1.8	5,421,394	271,070	19.5	81	7.2	11,249,865	138,887	40.5	88	7.8	6,290,786	71,486	22.6
Maryland	2	1.4	541,994	270,997	11.5	13	9.4	1,889,229	145,325	39.8	18	12.9	1,351,406	75,078	28.5
Michigan						7	31.8	898,061	128,294	65.3	6	27.3	425,463	70,911	30.9
Missouri	6	1.2	1,490,270	248,378	26.3	5	.9	631,495	126,299	11.1	25	4.9	1,817,149	72,686	32.0
Montana	7	7.4	2,801,245	400,178	66.3	4	4.3	604,741	151,185	14.3	9	9.6	560,024	62,225	13.3
New Mexico	9	20.0	2,782,089	309,121	69.5	5	11.1	648,321	129,664	16.2	5	11.1	385,953	77,191	9.6
North Dakota						2	1.1	260,263	130,132	32.9	1	.5	73,276	73,276	9.3
Ohio	61	4.3	17,686,225	289,938	43.4	86	6.1	12,288,999	142,895	30.2	72	5.1	5,106,454	70,922	12.5
Oklahoma	2	1.3	412,448	206,224	9.4	8	5.4	986,002	123,250	22.5	18	12.1	1,367,261	75,959	31.2
Oregon															
Pennsylvania	268	10.4	100,594,862	375,354	58.3	243	9.5	33,489,396	137,816	19.5	267	10.4	19,294,682	72,265	11.2
South Dakota															
Tennessee	7	4.5	1,781,717	254,531	28.7	10	6.5	1,445,445	144,545	23.4	22	14.2	1,555,855	70,721	25.1
Texas	1	2.1	204,625	204,625	8.7	5	10.4	747,974	149,595	31.8	9	18.7	575,951	63,995	24.4
Utah	10	27.8	3,544,808	354,481	85.9	3	8.3	402,662	134,221	9.8	1	2.8	60,579	60,579	1.5
Virginia	14	10.1	6,926,711	494,765	68.7	8	5.7	1,055,490	131,936	10.5	21	15.1	1,450,682	69,080	14.4
Washington	8	14.3	2,141,180	267,648	53.3	6	10.7	808,157	134,693	20.2	7	12.5	458,800	65,543	11.4
West Virginia	94	5.8	28,545,525	303,676	33.0	197	12.2	28,492,230	144,631	33.0	248	15.3	17,987,484	72,530	20.8
Wyoming	23	31.1	6,521,244	283,532	76.0	9	12.2	1,473,549	163,728	17.2	6	8.1	421,382	70,230	4.9
Grand total	792	7.5	285,365,741	360,310	51.7	914	8.6	129,485,524	141,669	23.5	1,044	9.8	74,804,269	71,738	13.5

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Bituminous coal produced in the United States in 1917, according to classes of mines—Continued.

State.	Fourth class (mines producing from 10,000 to 50,000 tons).					Fifth class (mines producing less than 10,000 tons).					Total.		
	Mines.		Quantity.			Mines.		Quantity.			Mines.	Quantity (net tons).	Average per mine (net tons).
	Number.	Percentage.	Total (net tons).	Average per mine (net tons).	Percentage.	Number.	Percentage.	Total (net tons).	Average per mine (net tons).	Percentage.			
Alabama	77	26.9	2,023,857	26,284	10.1	112	39.1	339,068	3,027	1.7	287	20,068,078	69,924
Arkansas	34	29.8	682,868	20,084	31.9	65	57.0	151,790	2,335	7.1	114	2,143,581	18,803
California, Idaho, and Alaska						7	100.0	60,401	8,629	100.0	7	60,401	8,629
Colorado	60	23.7	1,601,767	26,696	12.8	120	47.5	259,941	2,166	2.1	253	12,483,337	49,341
Georgia						1	50.0	1,625	1,625	1.4	2	119,028	59,514
Illinois	75	9.9	1,994,809	26,598	2.3	410	53.9	726,064	1,771	.9	761	86,199,377	113,271
Indiana	46	11.1	1,085,123	23,590	4.1	245	59.1	350,096	1,429	1.3	414	26,539,329	64,105
Iowa	39	17.9	1,047,879	26,869	11.7	116	53.2	269,000	2,319	3.1	218	8,965,830	41,128
Kansas	42	22.6	1,205,403	28,700	16.7	90	48.3	170,114	1,890	2.3	186	7,184,975	38,629
Kentucky	150	13.3	4,093,432	27,290	14.7	780	69.9	752,475	954	2.7	1,128	27,807,952	24,662
Maryland	29	20.9	857,764	29,578	18.0	77	55.4	105,531	1,371	2.2	139	4,745,924	34,143
Michigan	2	9.1	23,595	11,798	1.7	7	31.8	27,686	3,955	2.1	22	1,374,805	62,491
Missouri	50	9.9	1,264,850	25,297	22.3	422	83.1	466,785	1,106	8.3	508	5,670,549	11,163
Montana	7	7.4	161,773	23,110	3.8	67	71.3	98,906	1,476	2.3	94	4,226,689	44,965
New Mexico	7	15.6	128,454	18,351	3.3	19	42.2	55,710	2,932	1.4	45	4,000,327	88,901
North Dakota	14	7.4	253,443	18,103	32.1	171	91.0	203,566	1,190	25.7	188	790,548	4,205
Ohio	178	12.7	4,084,381	22,665	9.9	1,010	71.8	1,632,674	1,617	4.0	1,407	40,748,733	28,961
Oklahoma	59	39.6	1,505,475	25,517	34.3	62	41.6	115,658	1,865	2.6	149	4,386,844	29,442
Oregon	1	16.7	10,055	10,055	35.5	5	83.3	18,272	3,654	64.5	6	28,327	4,721
Pennsylvania	626	24.4	16,088,564	25,621	9.3	1,162	45.3	3,080,638	2,608	1.7	2,566	172,448,142	67,205
South Dakota						12	100.0	8,042	670	100.0	12	8,042	670
Tennessee	53	34.2	1,288,228	24,306	20.8	63	40.6	122,976	1,952	2.0	155	6,194,221	39,963
Texas	26	54.2	792,063	30,464	33.6	7	14.6	35,202	5,029	1.5	48	2,355,815	49,079
Utah	3	8.3	89,226	29,742	2.1	19	52.8	27,955	1,471	.7	36	4,125,230	114,590
Virginia	24	17.8	486,330	20,264	4.8	72	51.8	167,878	2,332	1.6	139	10,087,091	72,569
Washington	22	39.3	555,494	25,250	13.9	13	23.2	46,271	3,559	1.2	56	4,009,902	71,605
West Virginia	366	22.6	10,246,766	27,997	11.8	715	44.1	1,169,662	1,636	1.4	1,620	86,441,667	53,359
Wyoming	6	8.1	124,401	20,734	1.5	30	40.5	35,043	1,168	.4	74	8,575,619	115,887
Grand total	1,996	18.8	51,596,000	25,850	9.4	5,888	55.3	10,449,029	1,775	1.9	10,684	551,790,563	51,884

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Bituminous coal produced in the United States in 1918, according to classes of mines.

State.	First class (mines producing more than 200,000 tons).					Second class (mines producing from 100,000 to 200,000 tons).					Third class (mines producing from 50,000 to 100,000 tons).				
	Mines.		Quantity.			Mines.		Quantity.			Mines.		Quantity.		
	Number.	Percentage.	Total (net tons)	Average per mine (net tons).	Percentage.	Number.	Percentage.	Total (net tons).	Average per mine (net tons).	Percentage.	Number.	Percentage.	Total (net tons).	Average per mine (net tons).	Percentage.
Alabama	23	7.3	8,671,854	377,037	45.2	22	7.0	2,923,182	132,872	15.2	58	17.9	4,045,585	72,248	21.1
Arkansas	1	0.9	279,008	279,008	12.5	2	1.7	243,145	121,572	10.9	7	5.9	482,421	68,917	21.7
California, Idaho, and Alaska											1	7.7	54,911	54,911	66.9
Colorado	14	5.6	3,903,704	278,836	31.5	32	12.8	4,553,356	142,292	36.7	27	10.8	1,850,718	68,545	14.9
Georgia											1	50.0	64,996	64,996	97.4
Illinois	163	23.6	70,613,379	433,211	79.1	78	11.3	11,427,952	146,512	12.8	59	8.5	4,364,317	73,971	4.9
Indiana	49	11.8	16,303,309	332,721	53.1	60	14.5	8,707,158	145,119	28.4	46	11.1	3,656,515	79,489	11.9
Iowa	7	3.2	1,881,356	268,765	23.0	16	7.3	2,126,367	132,898	26.0	32	14.5	2,396,060	74,877	29.3
Kansas	4	1.6	846,942	211,736	11.2	17	6.8	2,350,643	138,273	31.1	36	14.5	2,589,397	71,928	34.2
Kentucky	25	2.2	6,586,987	263,479	20.8	73	6.5	10,144,724	138,969	32.1	102	9.1	7,975,095	78,187	25.2
Maryland	2	1.5	441,054	220,527	9.8	10	7.6	1,325,441	132,544	29.5	19	14.5	1,327,444	69,865	29.5
Michigan						5	18.6	663,710	132,742	45.3	9	33.3	689,039	76,560	47.0
Missouri	3	0.7	784,897	261,632	13.9	12	2.8	1,646,025	137,169	29.0	21	4.9	1,416,329	67,444	25.0
Montana	5	5.1	2,515,373	503,075	55.5	10	10.1	1,411,363	141,136	31.1	2	2.0	121,276	60,638	2.7
New Mexico	9	20.5	2,661,968	295,774	66.1	7	15.9	839,793	119,970	20.9	3	6.8	213,880	71,293	5.3
North Carolina															
North Dakota	1	0.6	299,310	299,310	41.6										
Ohio	69	5.1	20,017,847	290,114	43.7	78	5.8	11,448,256	146,773	25.0	88	6.6	6,738,989	76,579	14.7
Oklahoma						13	8.2	1,643,980	126,460	34.1	22	13.9	1,588,112	71,960	32.9
Oregon															
Pennsylvania	291	10.1	99,486,249	341,877	55.7	236	8.2	33,905,360	143,667	19.0	289	10.0	21,092,499	72,984	11.8
South Dakota															
Tennessee	6	3.3	1,469,251	244,875	21.5	16	8.7	2,005,945	125,372	29.4	27	14.7	1,887,397	69,904	27.6
Texas						6	12.8	819,407	136,568	36.3	10	21.2	669,597	66,960	29.6
Utah	11	19.3	4,246,781	386,071	82.7	3	5.3	455,628	151,876	8.9	4	7.0	304,440	76,110	5.9
Virginia	12	6.3	5,426,441	452,203	52.7	16	8.5	2,077,010	129,813	20.2	21	11.1	1,435,274	68,346	13.9
Washington	7	12.7	1,969,245	281,321	48.2	6	10.9	843,233	140,539	20.7	9	16.4	604,481	67,165	14.8
West Virginia	99	5.6	26,687,159	269,567	29.7	197	11.3	27,196,355	138,053	30.2	296	17.0	20,766,583	70,157	23.1
Wyoming	20	24.4	6,174,728	308,736	65.5	14	17.1	2,269,277	162,091	24.0	11	13.4	812,549	73,868	8.6
Grand total	821	7.4	281,266,842	342,591	48.5	929	8.4	131,027,310	141,041	22.6	1,198	10.9	87,142,904	72,740	15.0

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Bituminous coal produced in the United States in 1918, according to classes of mines—Continued.

State.	Fourth class (mines producing from 10,000 to 50,000 tons).					Fifth class (mines producing less than 10,000 tons).					Total.		
	Mines.		Quantity.			Mines.		Quantity.			Mines.	Quantity (net tons).	Average per mine (net tons).
	Number.	Percentage.	Total (net tons).	Average per mine (net tons).	Percentage.	Number.	Percentage.	Total (net tons).	Average per mine (net tons).	Percentage.			
Alabama	116	37.1	3,098,327	26,710	16.2	96	30.7	446,014	4,646	2.3	313	19,184,962	61,294
Arkansas	36	30.8	991,390	27,539	44.5	71	60.7	231,405	3,259	10.4	117	2,227,369	19,037
California, Idaho, and Alaska						12	92.3	27,095	2,258	33.1	13	82,008	6,308
Colorado	70	28.0	1,849,317	26,419	14.9	107	42.8	259,476	2,341	2.0	250	12,407,571	49,630
Georgia						1	50.0	1,720	1,720	2.6	2	66,716	33,358
Illinois	92	13.3	2,373,553	25,799	2.7	299	43.3	511,905	1,712	0.5	691	89,291,105	129,220
Indiana	64	15.5	1,646,582	25,728	5.4	195	47.1	365,070	1,872	1.2	414	30,678,634	74,102
Iowa	56	25.2	1,550,487	27,687	18.9	110	49.8	237,925	2,163	2.8	221	8,192,195	37,069
Kansas	48	19.3	1,382,444	28,801	18.3	144	57.8	392,521	2,726	5.2	249	7,561,947	30,369
Kentucky	246	22.0	5,725,724	23,275	18.1	673	60.2	1,180,087	1,753	3.8	1,119	31,612,617	28,251
Maryland	46	35.2	1,269,473	27,597	28.2	54	41.2	133,885	2,479	3.0	131	4,497,297	34,331
Michigan	4	14.8	100,633	25,158	6.9	9	33.3	11,436	1,271	0.8	27	1,464,818	54,253
Missouri	52	12.3	1,351,440	25,989	23.8	336	79.3	469,039	1,396	8.3	424	5,667,730	13,367
Montana	12	12.1	384,217	32,018	8.5	70	70.7	109,276	1,483	2.2	99	4,532,505	45,783
New Mexico	10	22.7	268,179	26,818	6.7	15	34.1	39,419	2,628	1.0	44	4,022,289	91,437
North Carolina						1	100.0	1,420	1,420	100.0	1	1,420	1,420
North Dakota	11	6.6	220,983	20,085	30.7	154	92.8	199,485	1,295	27.7	166	719,783	4,336
Ohio	244	13.2	5,945,438	24,367	13.0	864	64.3	1,662,393	1,924	3.6	1,343	45,812,943	34,112
Oklahoma	54	34.2	1,413,602	26,178	29.4	60	43.7	172,753	2,504	3.6	158	4,813,447	30,465
Oregon						3	100.0	13,328	4,443	100.0	3	13,328	4,443
Pennsylvania	802	27.8	20,173,442	25,154	11.3	1,264	43.9	3,898,191	3,080	2.2	2,882	178,550,741	61,954
South Dakota						12	100.0	7,942	662	100.0	12	7,942	662
Tennessee	56	30.4	1,245,283	22,237	18.2	79	42.9	223,172	2,825	3.3	184	6,831,048	37,125
Texas	25	53.2	735,641	29,426	32.5	6	12.8	36,490	6,082	1.6	47	2,261,135	48,108
Utah	3	5.3	104,893	34,964	2.0	36	63.1	25,083	697	0.5	57	5,126,825	90,120
Virginia	45	23.8	1,013,371	22,519	9.9	95	50.3	337,712	3,555	3.3	189	10,289,808	54,443
Washington	23	41.8	626,366	27,233	15.3	10	18.2	38,887	3,889	1.0	55	4,082,212	74,222
West Virginia	515	29.5	13,817,739	26,831	15.4	638	36.6	1,468,008	2,301	1.6	1,745	89,985,839	51,539
Wyoming	6	7.3	164,207	27,368	1.7	31	37.8	17,927	578	0.2	82	9,438,688	115,106
Grand total	2,636	23.9	67,452,705	25,589	11.7	5,454	49.4	12,496,059	2,291	2.2	11,088	579,285,830	52,490

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NATURAL GAS.[1]

By E. G. Sievers.

PRODUCTION.

The peak of the production of natural gas in the United States was reached in 1917, the production in 1918 being 9 per cent less in volume, a decline which was probably continued during 1919. The total output in 1918 was 721,000,959,000 cubic feet, a decrease of 74,109,417,000 cubic feet, which is accounted for by the falling off in West Virginia, Oklahoma, Pennsylvania, Ohio, and California.

Twenty-seven States produced natural gas in 1918. The chief producing States, in the order of output, were West Virginia, Oklahoma, Pennsylvania, Ohio, California, Louisiana, Kansas, and Texas. Of the producing States 8 increased in output, 15 decreased, and 4 were credited with a production for the first time.

Despite the decrease in output in 1918 the market value was $153,553,560, a gain of $11,464,226, or 8 per cent, over the value in 1917. The average price in 1918 at the point of consumption was 21.29 cents per thousand cubic feet, a gain of 3.42 cents, or 19 per cent.

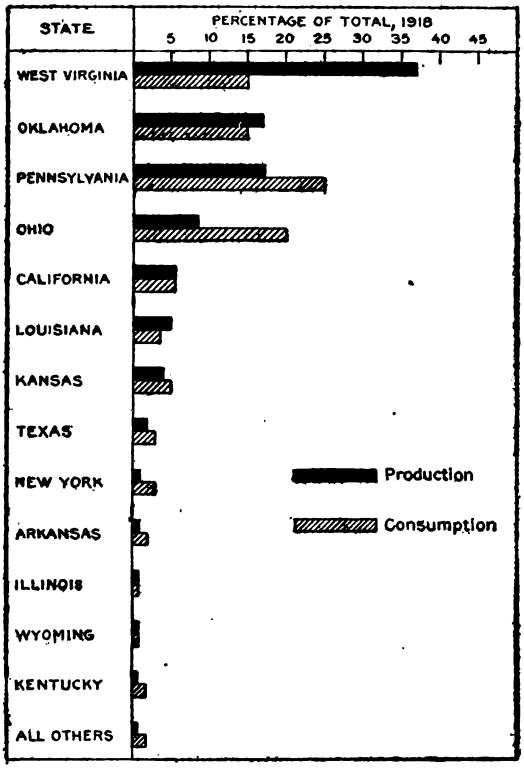

FIGURE 118.—Distribution by States of the natural gas produced and consumed in the United States in 1918.

At the end of 1918 there were 40,869 wells producing natural gas, a little over 1,000 more than at the end of 1917. Activities during 1918 resulted in the drilling of 5,316 wells, of which 3,808, or 72 per

[1] The statistical tables were compiled by Miss M. E. Cox, of the United States Geological Survey. The preparation of this report has been unavoidably delayed. Only a summary statement is presented, therefore, in addition to the tables.

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cent, were successful gas wells, and 1,508, or 28 per cent, were dry. A total of 2,722 wells were abandoned during the year.

At the end of 1918 the total acreage of natural-gas lands, including reserves, was 14,578,056 acres, which was 866,093 acres less than at the end of 1917.

CONSUMPTION.

GENERAL.

One of the most interesting as well as important features of the consumption of natural gas in 1918 was the increased use for domestic purposes—lighting, heating, and cooking—and the decreased consumption in the industries. This result is directly in line with the aims of the conservation movement, namely, to curtail the quantity of gas entering the industries and thus leave a greater supply for domestic consumption, and one of the factors causing this result was the restriction by some State public-service commissions of industrial sales of gas between November 1 and May 1. During the summer, when the demand for domestic gas drops, more gas is again sold to industrial establishments.

The principal consuming States in 1918 were Pennsylvania, Ohio, West Virginia, Oklahoma, California, Kansas, Louisiana, New York, Texas, Arkansas, and Kentucky, which together consumed 701,068,684,000 cubic feet of natural gas, or 97 per cent of the total consumption in the United States. Approximately 78 per cent of the natural gas produced in 1918 was consumed in the States where it was produced, the remaining 22 per cent being piped out for consumption in neighboring States. Pennsylvania alone consumed 25 per cent and Ohio 20 per cent of the total in 1918.

DOMESTIC.

In 1918 2,508,543 domestic consumers used 271,102,298,000 cubic feet of gas, or 38 per cent of the total volume consumed in the United States. This was a gain, as compared with 1917, of 3 per cent in the number of consumers and of 5 per cent in the quantity of gas consumed, which bears out the increased tendency already referred to for a greater utilization of natural gas for domestic purposes. Ohio, Pennsylvania, Oklahoma, West Virginia, New York, and Kansas are the largest users of the domestic gas.

The market value of the natural gas used for domestic purposes was $85,003,742, a gain of $5,580,113, or 7 per cent. The average price per thousand cubic feet of domestic gas in 1918 was 31.35 cents, slightly more than the average price in 1917.

The average annual consumption per domestic consumer was 108,000 cubic feet and the average monthly consumption was about 9,000 cubic feet, practically the same as in 1917.

INDUSTRIAL.

Industrial establishments numbering 16,581 in 1918 consumed 449,898,661,000 cubic feet of natural gas, or 62 per cent of the total consumption in the United States. Of these establishments, 82 per

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cent were in Pennsylvania, Ohio, West Virginia, Oklahoma, California, and Kansas, and they consumed 86 per cent of the total industrial gas used in the United States. A decrease of 11 per cent in the number of industrial consumers and of 16 per cent in the volume of gas utilized in the industries in 1918 shows the results of the policy of curtailing the use of natural gas in industrial plants. About 261,278,897,000 cubic feet, or 58 per cent of the gas utilized for industrial purposes in 1918, was consumed in manufacturing, in furnaces, kilns, and ovens, in the manufacture of brick, cement, pottery, and glass, and in the smelting of ores. The remaining 188,619,764,000 cubic feet, or 42 per cent, was used as fuel in the generation of power. Of the total number of industrial consumers, 5,986 used natural gas in manufacturing and 10,595 used gas for generating power.

The market value attributed to the total volume consumed in the industries in 1918 was $68,549,818, of which $45,913,824 was the value of the natural gas used in manufacturing and $22,635,994 that of the gas used for power.

The average consumption of natural gas per industrial consumer was 27,133,000 cubic feet annually and 2,261,000 cubic feet monthly.

Natural gas produced and consumed in the United States in 1917.

State.	Production.			Consumption.		
	Volume (M cubic feet).	Average price (cents per M cubic feet).	Value.	Volume (M cubic feet).	Average price (cents per M cubic feet).	Value.
West Virginia	308,617,101	18.60	$57,389,161	[a] 115,488,192	9.14	$10,558,612
Oklahoma	137,384,154	10.18	13,984,656	[b] 122,177,676	8.92	10,900,827
Pennsylvania	133,397,206	21.53	28,716,492	202,259,498	20.16	40,773,689
Ohio	68,917,231	26.75	18,434,814	165,782,369	26.99	44,742,782
California	49,427,331	13.79	6,816,524	49,427,331	13.79	6,816,524
Louisiana	31,286,476	10.43	3,262,987	[c] 31,286,476	10.43	3,262,987
Kansas	24,438,848	23.33	5,701,436	[d] 37,962,357	22.29	8,463,767
Texas	17,047,292	18.73	3,192,625	17,901,637	19.18	3,433,123
New York	8,371,747	29.85	2,499,303	22,466,348	30.77	6,912,540
Arkansas	5,609,484	5.63	315,612	[e] 6,437,008	6.16	396,612
Illinois	4,439,016	10.79	479,072	[f] 4,439,016	10.79	479,072
Kentucky	2,802,079	20.71	580,380	12,053,445	25.84	3,114,402
Indiana	1,711,454	26.49	453,310	5,766,466	34.19	1,971,435
Wyoming, Colorado	1,223,136	11.81	144,425	1,223,136	11.81	144,425
Montana	334,421	24.34	81,406	334,421	24.34	81,406
South Dakota, Alabama, North Dakota	59,666	42.26	25,213	59,666	42.26	25,213
Missouri	31,425	26.19	8,230	31,425	26.19	8,230
Tennessee	10,900	22.48	2,450	10,900	22.48	2,450
Michigan	1,184	85.55	1,013	1,184	85.55	1,013
Iowa	225	100.00	225	225	100.00	225
	795,110,376	17.87	142,089,334	795,110,376	17.87	142,089,334

[a] Includes gas piped from West Virginia and consumed in Maryland.
[b] Includes gas piped from Oklahoma and consumed in Missouri.
[c] Includes gas piped from Louisiana and consumed in Arkansas and Texas
[d] Includes gas piped from Kansas and consumed in Missouri.
[e] Includes gas piped from Oklahoma.
[f] Includes gas piped from Illinois and consumed in Indiana.

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Natural gas produced and consumed in the United States in 1918.

State.	Production.				Consumption.			
	Percentage.	Volume (M cubic feet).	Average price (cents per M cubic feet).	Value.	Percentage.	Volume (M cubic feet).	Average price (cents per M cubic feet).	Value.
West Virginia	36.78	265,160,917	15.58	$41,324,365	15.07	108,673,444	11.30	$12,284,789
Oklahoma	17.24	124,317,179	12.71	15,805,135	14.79	106,661,404	11.92	12,724,284
Pennsylvania	17.17	123,813,358	31.18	38,608,883	24.57	177,139,804	25.27	44,777,220
Ohio	8.50	61,261,069	39.55	24,234,741	19.92	143,585,260	30.43	43,694,161
California	5.51	39,718,941	20.01	7,951,666	5.51	39,718,941	20.01	7,951,666
Louisiana	5.01	36,094,132	13.60	4,912,235	3.65	26,324,150	9.86	2,597,035
Kansas	3.86	27,824,641	23.86	6,640,781	4.71	33,912,283	20.83	7,064,213
Texas	1.86	13,439,624	37.40	5,027,149	2.81	20,282,713	27.20	5,518,482
New York	1.17	8,460,583	67.05	5,673,131	2.82	20,341,207	33.32	6,779,297
Arkansas	.73	5,294,663	10.86	575,115	1.70	12,229,288	16.11	1,971,189
Illinois	.62	4,473,018	13.88	620,949	.62	4,473,018	13.88	620,949
Wyoming	.60	4,338,840	3.59	156,171	.60	4,338,840	3.59	156,171
Kentucky	.42	3,022,439	22.03	665,843	1.69	12,200,190	25.35	3,093,288
Tennessee		1,826,725	19.76	361,140		1,826,725	19.76	361,140
Indiana		1,666,822	53.97	899,671		4,516,583	33.44	1,510,404
Montana		177,039	35.10	62,148		177,039	35.10	62,148
South Dakota		42,186	45.29	19,109		42,186	45.29	19,109
Maryland, Utah, Washington	.53	25,916	10.41	2,700	1.54	25,916	10.41	2,700
Missouri		22,120	25.08	5,548		4,511,221	52.28	2,358,544
Colorado		10,103	25.48	2,575		10,103	25.48	2,575
Alabama		4,600	41.08	1,890		4,600	41.08	1,890
Oregon		2,200	25.00	550		2,200	25.00	550
Iowa		1,758	13.93	245		1,758	13.93	245
Michigan		1,173	89.08	1,045		1,173	89.08	1,045
North Dakota		913	52.02	475		913	52.02	475
	100.00	721,000,959	21.29	153,553,560	100.00	721,000,959	21.29	153,553,560

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Distribution of natural gas consumed in the United States in 1917 and 1918.

1917.

State.	Number of producers.	Consumers.		Gas consumed.		
				Domestic.		
		Domestic.	Industrial.	Volume (M cubic feet).	Average price (cents per M cubic feet).	Value.
Ohio	2,320	872,073	4,743	101,584,452	30.96	$31,455,004
Pennsylvania	1,613	480,500	4,417	63,135,783	28.69	18,110,975
Oklahoma [a]	565	94,605	2,183	12,873,023	20.29	2,612,468
West Virginia [b]	521	129,297	2,047	21,258,009	18.82	3,999,333
Kansas [c]	462	188,043	1,018	8,928,425	58.64	5,235,274
New York	349	164,308	698	20,737,081	31.42	6,516,536
California	100	239,448	1,038	4,914,374	68.03	3,343,443
Texas	85	73,706	854	7,194,724	34.25	2,464,099
Louisiana [d]	95	35,277	703	4,682,339	29.79	1,394,951
Kentucky	118	90,041	124	7,354,153	33.95	2,496,814
Indiana	941	42,322	497	3,475,321	37.55	1,305,137
Illinois [e]	225	11,622	118	481,770	34.67	167,023
Arkansas [f]	15	6,874	125	1,009,307	15.24	153,807
Wyoming	25	1,014	20	198,993	34.42	68,495
Colorado	17	7	5			
Montana	6	1,216	12	279,859	26.87	75,206
South Dakota	26	412	5	25,721	62.03	15,955
Alabama	10	119	3			
North Dakota	11	4	.....			
Missouri	41	372	6	28,085	26.33	7,395
Tennessee	12	4	3	750	50.00	375
Michigan	10	9	1	613	100.00	613
Iowa	6	2	.....	225	100.00	225
	7,573	2,431,275	18,620	258,163,007	30.76	79,423,629

State.	Gas consumed.					
	Industrial.			Total.		
	Volume (M cubic feet).	Average price (cents per M cubic feet).	Value.	Volume (M cubic feet).	Average price (cents per M cubic feet).	Value.
Ohio	64,197,917	20.70	$13,287,778	165,782,369	26.99	$44,742,782
Pennsylvania	139,123,715	16.29	22,662,714	202,259,498	20.16	40,773,689
Oklahoma [a]	109,304,653	7.58	8,288,359	122,177,676	8.92	10,900,827
West Virginia [b]	94,230,183	6.96	6,558,779	115,488,192	9.14	10,558,612
Kansas [c]	29,034,432	11.12	3,228,493	37,962,857	22.29	8,463,767
New York	1,729,767	22.89	396,002	22,466,848	30.77	6,912,540
California	44,512,957	7.80	3,473,081	49,427,331	13.79	6,816,524
Texas	10,706,913	9.05	969,024	17,901,637	19.18	3,433,123
Louisiana [d]	26,604,137	7.02	1,868,036	31,286,476	10.43	3,262,987
Kentucky	4,699,292	13.14	617,588	12,053,445	25.84	3,114,402
Indiana	2,291,145	29.08	666,298	5,766,466	34.19	1,971,435
Illinois [e]	3,957,246	7.89	312,049	4,439,016	10.79	479,072
Arkansas [f]	5,428,301	4.48	242,805	6,437,608	6.16	396,612
Wyoming	1,024,143	7.41	75,930	1,223,136	11.81	144,425
Colorado						
Montana	54,562	11.37	6,201	334,421	24.34	81,406
South Dakota						
Alabama	33,945	27.27	9,258	59,666	42.26	25,213
North Dakota						
Missouri	3,340	25.00	835	31,425	26.19	8,230
Tennessee	10,150	20.44	2,075	10,900	22.48	2,450
Michigan	571	70.05	400	1,184	85.56	1,013
Iowa	.....	.....	.....	225	100.00	225
	536,947,369	11.67	62,665,705	795,110,376	17.87	142,089,334

[a] Includes some gas piped from Oklahoma to Missouri.
[b] Includes some gas piped from West Virginia to Maryland.
[c] Includes some gas piped from Kansas to Missouri.
[d] Includes some gas piped to Texas and to Arkansas from Louisiana.
[e] Includes some gas piped from Illinois to Vincennes, Ind.
[f] Includes some gas piped from Oklahoma to Arkansas.

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Distribution of natural gas consumed in the United States in 1917 and 1918—Continued.

1918.

State.	Number of producers.	Consumers.		Gas consumed.		
				Domestic.		
		Domestic.	Industrial.	Volume (M cubic feet).	Average price (cents per M cubic feet).	Value.
Ohio	2,359	885,876	4,010	98,023,666	32.36	$31,721,005
Pennsylvania	1,509	481,275	4,486	59,839,730	31.37	18,772,970
New York	342	169,308	641	19,637,845	33.60	6,599,907
Kansas	412	120,350	877	14,808,432	29.97	4,439,202
West Virginia	407	127,168	1,873	20,968,624	21.02	4,408,125
Oklahoma	398	120,507	1,490	21,493,267	20.37	4,378,661
California	95	260,767	894	5,901,797	66.78	3,941,589
Texas	81	79,865	703	7,212,092	38.75	2,795,205
Kentucky	122	90,849	100	7,922,941	30.98	2,454,698
Missouri	34	84,038	186	4,054,772	54.80	2,222,346
Arkansas	12	21,742	226	3,551,314	31.10	1,104,589
Indiana	931	31,032	284	2,428,003	37.48	910,215
Louisiana	73	24,370	578	4,264,777	20.41	870,557
Illinois	186	8,699	90	598,758	40.38	241,824
Montana	6	1,198	1	176,727	35.10	62,046
Wyoming	25	999	46	189,010	32.34	61,128
South Dakota	31	391	2	20,166	67.46	13,604
Alabama	9	102	1	2,600	41.92	1,090
Tennessee	11	6	6	1,442	52.01	750
Michigan	19	12	2	745	100.00	745
Colorado	17	6	3	2,553	28.39	725
Oregon	3	3	.....	2,200	25.00	550
North Dakota	7	6	.....	913	52.02	475
Iowa	7	3	.....	1,758	13.93	245
Maryland, Utah, Washington	5	1	2	166	30.12	50
	7,101	2,508,543	16,581	271,102,298	31.35	85,003,742

State.	Gas consumed.					
	Industrial.			Total.		
	Volume (M cubic feet).	Average price (cents per M cubic feet).	Value.	Volume (M cubic feet).	Average price (cents per M cubic feet).	Value.
Ohio	45,561,694	26.27	$11,973,156	143,585,360	30.43	$43,694,161
Pennsylvania	117,300,074	22.16	26,004,250	177,139,804	25.27	44,777,220
New York	703,362	25.49	179,300	20,341,207	33.32	6,779,207
Kansas	19,103,851	13.74	2,625,016	33,912,283	20.83	7,064,218
West Virginia	87,704,820	8.97	7,875,664	108,673,444	11.30	12,284,789
Oklahoma	85,168,137	9.79	8,344,703	106,661,404	11.92	12,724,364
California	33,817,144	11.85	4,010,106	39,718,941	20.01	7,951,666
Texas	13,070,621	20.83	2,723,197	20,282,713	27.20	5,518,462
Kentucky	4,277,249	14.92	638,457	12,200,190	25.35	3,093,383
Missouri	456,449	29.83	136,198	4,511,221	52.28	2,358,544
Arkansas	8,677,974	9.98	866,571	12,229,288	16.11	1,971,100
Indiana	2,088,580	28.73	600,189	4,516,583	33.44	1,510,404
Louisiana	22,059,373	7.82	1,726,448	26,324,150	9.86	2,597,035
Illinois	3,876,260	9.80	379,925	4,473,018	13.88	620,949
Montana	312	32.05	100	177,039	35.10	62,148
Wyoming	4,140,330	2.29	96,043	4,338,840	3.59	156,171
South Dakota	22,020	25.00	5,505	42,186	45.29	19,109
Alabama	2,000	40.00	800	4,600	41.08	1,890
Tennessee	1,825,283	19.74	360,390	1,826,725	19.76	361,140
Michigan	428	70.09	300	1,173	89.08	1,045
Colorado	7,550	24.50	1,850	10,103	25.48	2,575
Oregon	.....	.....	.....	2,200	25.00	550
North Dakota	.....	.....	.....	913	52.02	475
Iowa	.....	.....	.....	1,758	13.93	245
Maryland, Utah, Washington	25,750	10.29	2,650	25,916	10.41	2,700
	449,898,661	15.23	68,549,818	721,000,959	21.29	153,553,580

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Distribution of natural gas consumed for industrial purposes in the United States in 1917 and 1918.

1917.

State.	Industrial consumers.			Gas consumed.		
				Manufacturing.		
	Manufacturing.	Other industrial (power).	Total.	Volume (M cubic feet).	Average price (cents per M cubic feet).	Value.
Pennsylvania	1,433	2,984	4,417	128,851,370	16.53	$20,477,083
Ohio	2,450	2,293	4,743	46,740,047	20.81	9,728,790
Oklahoma	369	1,814	2,183	48,435,989	6.20	3,001,611
West Virginia	1,208	839	2,047	70,771,137	6.98	4,938,675
California	.....	1,038	1,038	.....	.....	.....
Kansas	84	934	1,018	14,094,485	10.36	1,459,626
Louisiana	124	579	703	4,406,270	6.66	293,632
Texas	95	759	854	1,964,307	10.02	196,857
Indiana	428	69	497	2,022,169	29.91	604,896
Kentucky	23	101	124	3,933,329	11.99	471,809
New York	27	671	698	520,704	32.31	168,242
Illinois	1	117	118	(a)	.....	(a)
Arkansas	56	69	125	4,853,143	4.42	214,569
Wyoming	1	19	20	(a)	.....	(a)
Colorado	.....	5	5			
South Dakota	.....	5	5			
Alabama	.....	3	3	.....	.....	.....
Montana	1	11	12	(a)	.....	(a)
Tennessee	.....	3	3	.....	.....	.....
Missouri	.....	6	6	.....	.....	.....
Michigan	.....	1	1	.....	.....	.....
	6,300	12,320	18,620	321,593,450	12.92	41,555,740

State.	Gas consumed.					
	Other industrial (power).			Total industrial.		
	Volume (M cubic feet).	Average price (cents per M cubic feet).	Value.	Volume (M cubic feet).	Average price (cents per M cubic feet).	Value.
Pennsylvania	15,272,345	14.31	$2,185,681	139,123,715	16.29	$22,662,714
Ohio	17,457,870	20.39	3,558,968	64,197,917	20.70	13,287,778
Oklahoma	60,868,664	8.69	5,286,748	109,304,653	7.58	8,288,359
West Virginia	23,459,046	6.91	1,620,104	94,230,183	6.96	6,558,779
California	44,512,957	7.80	3,473,081	44,512,957	7.80	3,473,081
Kansas	14,939,947	11.84	1,768,867	29,034,432	11.12	3,228,493
Louisiana	22,197,867	7.09	1,574,404	26,604,137	7.02	1,868,036
Texas	8,742,606	8.83	772,167	10,706,913	9.05	969,024
Indiana	268,976	22.83	61,402	2,291,145	29.06	666,298
Kentucky	765,463	19.04	145,779	4,699,292	13.14	617,588
New York	1,209,063	18.84	227,760	1,729,767	22.89	396,002
Illinois	3,957,246	7.89	312,049	3,957,246	7.89	312,049
Arkansas	575,158	4.91	28,236	5,428,301	4.47	242,805
Wyoming	1,024,143	7.41	75,930	1,024,143	7.41	75,930
Colorado						
South Dakota	33,945	27.27	9,258	33,945	27.27	9,258
Alabama						
Montana	54,562	11.37	6,201	54,562	11.37	6,201
Tennessee	10,150	20.44	2,075	10,150	20.44	2,075
Missouri	3,340	25.00	835	3,340	25.00	835
Michigan	571	70.05	400	571	70.05	400
	215,353,919	9.80	21,109,965	536,947,369	11.67	62,665,705

a Included in "Other industrial."

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Distribution of natural gas consumed for industrial purposes in the United States in 1917 and 1918—Continued.

1918.

State.	Industrial consumers.			Gas consumed.		
				Manufacturing.		
	Manufacturing.	Other industrial (power).	Total.	Volume (M cubic feet).	Average price (cents per M cubic feet).	Value.
Pennsylvania	1,718	2,768	4,486	104,304,256	22.79	$23,775,400
Ohio	1,496	2,514	4,010	30,442,347	27.20	9,000,059
Oklahoma	210	1,270	1,480	25,061,884	7.46	1,870,616
West Virginia	1,026	847	1,873	62,835,225	9.38	5,896,318
California	265	629	894	1,442,949	37.57	542,167
Texas	251	542	793	4,538,852	33.35	1,513,334
Kansas	418	459	877	10,575,906	13.14	1,389,782
Louisiana	139	439	578	4,948,129	7.42	367,424
Arkansas	133	93	226	5,833,121	5.82	339,362
Kentucky	25	75	100	3,715,210	14.84	551,396
Indiana	229	55	284	1,446,267	31.75	459,322
Illinois	.....	90	90	.....	.....	.....
Tennessee	.....	6	6	.....	.....	.....
New York	26	615	641	209,325	22.89	47,927
Missouri	42	144	186	18,623	22.24	4,142
Wyoming	7	39	46	2,881,843	1.78	51,474
South Dakota	.....	2	2	.....	.....	.....
Maryland, Utah, Washington	1	1	2	25,000	10.00	2,500
Colorado	.....	3	3	.....	.....	.....
Alabama	.....	1	1	.....	.....	.....
Michigan	.....	2	2	.....	.....	.....
Montana	.....	1	1	.....	.....	.....
	5,986	10,595	16,581	261,278,897	17.57	45,913,834

State.	Gas consumed.					
	Other industrial (power).			Total industrial.		
	Volume (M cubic feet).	Average price (cents per M cubic feet).	Value.	Volume (M cubic feet).	Average price (cents per M cubic feet.)	Value.
Pennsylvania	12,995,818	17.15	$2,228,850	117,300,074	22.16	$26,004,250
Ohio	12,119,247	23.71	2,874,106	45,561,594	26.27	11,973,156
Oklahoma	60,106,253	10.77	6,474,087	85,168,137	9.79	8,344,703
West Virginia	24,869,595	7.94	1,976,846	87,704,820	8.97	7,875,664
California	32,374,195	10.71	3,467,939	33,817,144	11.85	4,010,106
Texas	8,531,769	14.17	1,209,373	13,070,621	20.83	2,723,197
Kansas	8,527,985	14.48	1,235,234	19,103,851	13.74	2,625,016
Louisiana	17,111,244	7.94	1,359,024	22,059,373	7.82	1,726,448
Arkansas	2,844,853	18.51	526,589	8,677,974	9.98	866,571
Kentucky	562,039	15.49	87,061	4,277,249	14.92	638,457
Indiana	642,313	21.98	140,867	2,088,580	28.73	600,189
Illinois	3,876,260	9.80	379,925	3,876,260	9.80	379,925
Tennessee	1,825,283	19.74	360,390	1,825,283	19.74	360,390
New York	494,037	26.59	131,373	703,362	25.49	179,300
Missouri	437,826	30.16	132,056	456,449	29.83	136,198
Wyoming	1,267,987	3.43	43,569	4,149,830	2.29	95,043
South Dakota	22,020	25.00	5,505	22,020	25.00	5,505
Maryland, Utah, Washington	750	20.00	150	25,750	10.29	2,650
Colorado	7,550	24.50	1,850	7,550	24.50	1,850
Alabama	2,000	40.00	800	2,000	40.00	800
Michigan	428	70.09	300	428	70.09	300
Montana	312	32.05	100	312	32.05	100
	188,619,764	12.00	22,635,994	449,898,661	15.23	68,549,818

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SUMMARY OF WELLS DRILLED.

Wells drilled for natural gas in 1918.

State.	Productive Dec. 31, 1917.	Drilled in 1918.			Abandoned in 1918.	Productive Dec. 31, 1918.
		Gas.	Dry.	Total.		
Alabama	24	4	4	8	5	23
Arkansas	113	6	.....	6	9	110
California	111	18	3	21	18	111
Colorado	13	.....	.....	.....	3	10
Illinois	267	11	21	32	44	254
Indiana	1,830	129	26	155	199	1,760
Iowa	7	2	.....	2	1	8
Kansas	2,579	334	229	563	604	2,309
Kentucky	286	45	25	70	21	310
Louisiana	269	46	18	64	38	277
Maryland	.....	3	.....	3	.....	3
Michigan	9	7	.....	7	1	15
Missouri	47	.....	.....	.....	7	40
Montana	15	2	2	4	4	13
New York	2,078	82	13	95	62	2,098
North Dakota	7	.....	.....	.....	.....	7
Ohio	5,979	614	297	911	425	6,168
Oklahoma	1,433	461	340	801	296	1,598
Oregon	a 4	.....	.....	.....	1	3
Pennsylvania	14,534	1,276	258	1,534	566	15,244
South Dakota	30	4	.....	4	5	29
Tennessee	12	4	8	12	2	14
Texas	250	27	86	113	46	231
Utah	.....	1	.....	1	.....	1
Washington	a 2	2	.....	2	.....	4
West Virginia	9,329	718	170	888	360	9,857
Wyoming	35	12	8	20	5	42
	39,283	3,808	1,508	5,316	2,722	40,369

a Small production not recorded.

ACREAGE CONTROLLED BY NATURAL-GAS PRODUCERS.

Land controlled by natural-gas producers in the United States in 1917 and 1918, in acres.

State.	1917				1918			
	In fee.	Leased.	Gas rights.	Total.	In fee.	Leased.	Gas rights.	Total.
Alabama	80	80,160	.....	80,240	80	80,160	.....	80,240
Arkansas	695	28,863	.....	29,558	295	26,817	.....	27,112
California	2,403	3,065	12,876	18,344	6,676	5,865	.....	12,541
Colorado	2,572	300	.....	2,872	2,732	11,000	.....	13,732
Illinois	406	182,440	60	182,906	733	138,533	1,307	140,573
Indiana	90,872	83,583	2,702	177,157	94,965	42,109	1,625	138,699
Iowa	.....	.....	.....	.....	120	.....	.....	120
Kansas	31,932	1,538,258	11,790	1,581,980	25,031	542,158	5,825	573,014
Kentucky	7,350	434,517	21,528	463,395	39,925	315,840	117	355,882
Louisiana	10,076	392,506	24,075	426,657	79,499	240,202	360	320,061
Maryland	.....	.....	.....	.....	.....	17,000	.....	17,000
Michigan	.....	.....	.....	.....	220	.....	.....	220
Missouri	780	3,000	.....	3,780	553	3,500	.....	4,053
Montana	2,280	42,900	.....	45,180	13,320	6,440	.....	19,760
New York	10,188	417,868	6,647	434,703	22,491	348,138	5,884	376,513
North Dakota	.....	.....	.....	.....	160	.....	.....	160
Ohio	26,226	2,215,312	18,490	2,260,028	54,346	2,359,801	147,276	2,561,423
Oklahoma	30,880	2,397,731	303,777	2,732,388	36,062	3,576,136	6,675	3,618,873
Pennsylvania	169,039	1,927,058	339,932	2,436,029	181,231	1,803,195	425,884	2,410,310
Tennessee	7	24,000	.....	24,007	1,597	17,560	335	19,492
Texas	24,221	643,821	27,790	695,832	95,774	390,704	1,200	487,678
Utah	.....	.....	.....	.....	1,280	17,000	.....	18,280
Washington	.....	.....	.....	.....	13,000	.....	.....	13,000
West Virginia	239,013	2,829,199	718,973	3,787,185	410,979	2,351,043	556,874	3,318,896
Wyoming	4,920	50,828	6,160	61,908	500	49,572	352	50,424
	653,940	13,295,409	1,494,800	15,444,149	1,081,569	12,342,773	1,153,714	14,578,056

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NATURAL-GAS GASOLINE.

By E. G. Sievers.[1]

INTRODUCTION.

GENERAL STATEMENT.

The term "natural-gas gasoline," as used by the United States Geological Survey, includes the gasoline recovered by all methods from both "wet" and "dry" natural gas and is synonymous with the term "casing-head gasoline," which is largely used in the industry. The terms "raw" and "unblended" gasoline are used interchangeably in this report, and "commercial" gasoline is the term applied to gasoline that has been blended with naphthas or distillates.

The completion of this report has been made possible by the hearty cooperation of the producers.

GROWTH OF THE INDUSTRY.

The natural-gas gasoline industry has made large contributions to the supply of motor fuel and has achieved remarkable advances since its beginning. In increasing the supply of motor fuel natural-gas gasoline is a direct means of conservation in that its extraction does not destroy the gas in which it is contained. Experiment has demonstrated that the extraction of gasoline from natural gas does not reduce appreciably the value of the gas for heat, power, and light, but that it is a benefit, for it removes not only the water but also the gasoline, which causes leakage by disintegrating the rubber gaskets in the pipes. Statistics covering the eight years from 1911 to 1918, inclusive, show that an estimated volume of 1,145,113,000 thousand cubic feet of natural gas was treated during that time in the manufacture of gasoline and that the total quantity of gasoline obtained was approximately 755,497,000 gallons. After furnishing this supply of gasoline, the natural gas treated was sent through transmission lines to distributing companies or direct to the consumers and utilized for fuel and light. The industry may therefore be compared favorably with the carbon-black industry, in which the natural gas is destroyed.

The natural-gas gasoline industry has also brought the oil and gas producers on the one hand and the refiners on the other into a closer relationship than existed prior to its development. The high volatility of natural-gas gasoline makes it necessary to reduce its gravity by blending with distillates or naphthas. These products formerly overstocked the refiner, but now that their use in this industry is

[1] The statistical tables in this report were compiled by Miss J. R. Penner, of the United States Geological Survey.

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becoming so large the supply is unequal to the demand. At the very outset of the industry it was demonstrated that the blending of the casing-head gasoline with heavier products, such as naphthas, was practicable. The naphthas and distillates alone had no great commercial use. They could not be used satisfactorily as a motor fuel because they were deficient in low-boiling fractions. The mixing of these products with natural-gas gasoline resulted in a well-balanced, ideal motor fuel.

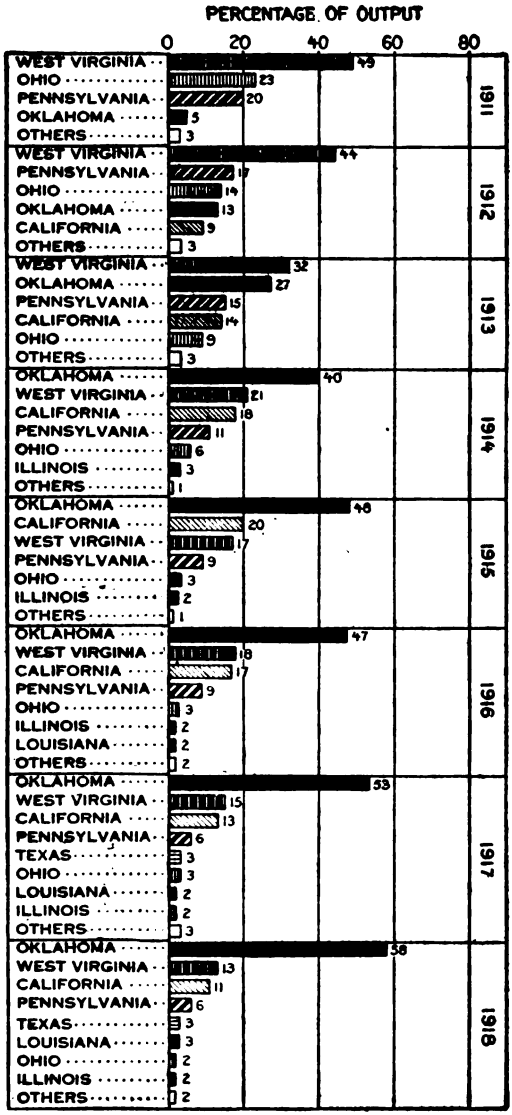

FIGURE 119.—Natural-gas gasoline produced in the United States, by States, 1911–1918.

The experiments of Fasenmeyer near Titusville, Pa., of Tompsett Bros. near Tidioute, Pa., and of Sutton Bros. at Sistersville, W. Va., as far back as 1903, laid the foundations of the natural-gas gasoline industry. Between 1905 and 1908 renewed efforts in experiments pertaining to the industry were made by Richards at Mayburg, Pa., Hollingshead at Bradford, Pa., McCarty at Bolivar, N. Y., Gray at Kinzua, Pa., and others. It was not until after 1909, however, that the industry was placed on a commercial basis.

Casing-head gasoline is extracted from natural gas chiefly by two methods, the compression method and the absorption method. Prior to 1916 the greater portion of the gasoline was recovered by the compression and vacuum-pump method from the "wet" gas obtained from oil wells. The largest output came from plants specially designed and installed for the recovery of the gasoline vapors in the gas of that type, but a certain proportion, especially in the Appalachian oil field, was incidentally recovered by the use of simple condensing apparatus connected with vacuum pumps installed to ex-

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pedite the production of oil. Some gasoline was recovered as drips from gas-transmission lines.

The development of the absorption process through research work done in 1912 and 1913 by G. M. Saybolt, a chemical engineer of the Hope Natural Gas Co., Pittsburgh, Pa., has been the chief means of increasing the production of casing-head gasoline. The introduction of this process has made it commercially possible to extract gasoline from "dry" gas that contains too little gasoline to warrant treatment by compression methods.

Although increasing the production of gasoline has been the paramount aim of those engaged in the industry, some attention has been given to the possibility of recovering liquid propane and butane in the process of extracting gasoline. The feasibility of recovering these substances has been shown both by experiments and by actual production. Liquid propane and butane have higher fuel values than natural gas, and their usefulness in cutting and welding metals, in heating and lighting, and as a source of power in stationary and automotive combustion engines has been demonstrated.

The natural-gas gasoline industry has grown rapidly. The first statistics of production collected, those for 1911, showed that 7,425,839 gallons of raw gasoline were in that year recovered at 176 plants in 9 States. During the eight years from 1911 to 1918 there was an increase of 470 per cent in the number of plants and of about 3,700 per cent in the production of raw gasoline. The marked increase in production in 1916 and 1917 was due to a greater demand for gasoline. This resulted in increased activity in plant construction and development, improvement of plant efficiency, and the treatment of a greater volume of natural gas. The rapid expansion of the industry is shown by the accompanying diagrams (figs. 119–122).

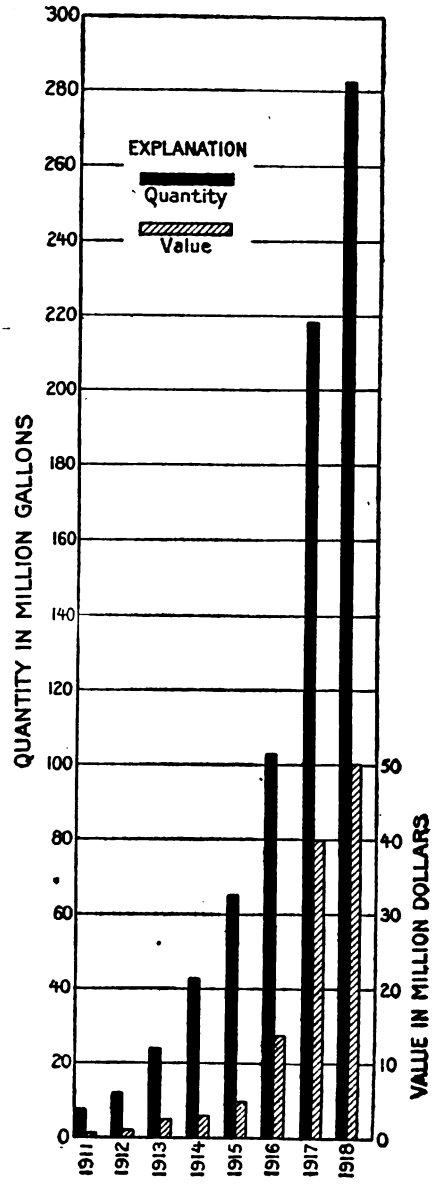

FIGURE 120.—Quantity and value of natural-gas gasoline produced in the United States, 1911–1918.

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PRODUCTION.

GENERAL STATEMENT.

The quantity of natural-gas gasoline produced in 1918 was about 30 per cent greater than that produced in 1917; the increase in 1917 over 1916 was 110.5 per cent. The total quantity of raw gasoline recovered in 1918 was 282,535,550 gallons, including that contributed by compression and vacuum pumps and by absorption and that recovered as drips from gas mains. In 1918 the compression plants, which are by far the largest producers, yielded 219,767,207 gallons, or 77.8 per cent of the total production. This quantity was 50,900,652 gallons, or 30.1 per cent, more than that supplied by the compression plants in 1917. The remaining 62,768,343 gallons, or 22.2 per cent of the total, was the product of the absorption plants and included drip gasoline collected from the mains. As compared

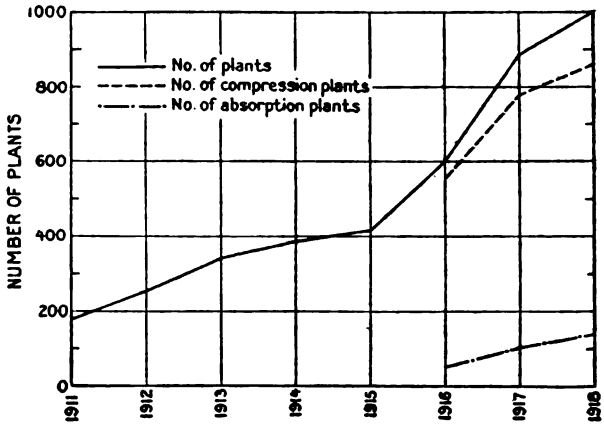

FIGURE 121.—Number of plants producing natural-gas gasoline in the United States, 1911-1918.

with the output by absorption in 1917, there was a gain in 1918 of 13,750,794 gallons, or 28.1 per cent. The average daily production of natural-gas gasoline in 1918 was 774,070 gallons.

The total output of gasoline in the United States in 1918 was 3,749,892,317 gallons.[1] Of this total output 3,467,356,767 gallons, or 92.5 per cent, was manufactured from crude petroleum by distillation, and the remaining 282,535,550 gallons, or 7.5 per cent, was natural-gas gasoline.

The outstanding feature of the industry in 1918 was the large increase in production by the compression plants in Oklahoma. Although the increase in output in Kansas in 1918 was 103 per cent, as compared with an increase of 42.2 per cent in Oklahoma, the contribution made by Oklahoma to the total output of natural-gas gasoline in the United States in 1918 was 48,577,126 gallons more than in 1917, whereas Kansas increased the total supply by only 1,214,876 gallons more than in 1917.

Of the 13 States engaged in the industry, 9 showed increases in production and 3 showed decreases. Wyoming made its first

[1] From statistics compiled by Bureau of Mines.

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production in 1918. The States which increased their output during the year, listed in the order of percentage of increase, were as follows: Kansas, 103 per cent; Oklahoma, 42.2 per cent; Louisiana, 41 per cent; New York, 40.8 per cent; Ohio, 24 per cent; West Virginia, 15.1 per cent; Pennsylvania, 14.1 per cent; California, 12 per cent; and Texas, 5.9 per cent. The States which decreased their output are Colorado, 90.6 per cent; Kentucky, 12.8 per cent; and Illinois, 7.3 per cent.

In 1917 Ohio held sixth place and Louisiana held seventh place, but in 1918 the places of the two States were reversed.

The quantity of commercial gasoline produced in 1918 by blending the raw gasoline with distillates was 262,611,267 gallons, and the value was $52,163,133.

The estimated market value of the output of raw gasoline in 1918 was $50,363,535, an increase over the value in 1917 of $10,174,579, or 25.3 per cent. In 1918 the value of the product of the compression plants was $37,644,649, or 74.7 per cent of the total market value, and the value of the product of the absorption plants and of the drip from the mains was $12,718,886, or 25.3 per cent of the total. The average price received for the unblended gasoline at the sources of production in 1917 was 18.45 cents a gallon; in 1918 the average price dropped to 17.8 cents a gallon, a decrease of 3.4 per cent. The average selling price of the raw gasoline produced at the compression plants in 1918 was 17.1 cents a gallon—a decrease of 1 cent a gallon, or 5.5 per cent—and that of the raw gasoline recovered at the absorption plants and from the mains as drip was 20.3 cents a gallon—a gain of 0.69 cent, or 3.5 per cent.

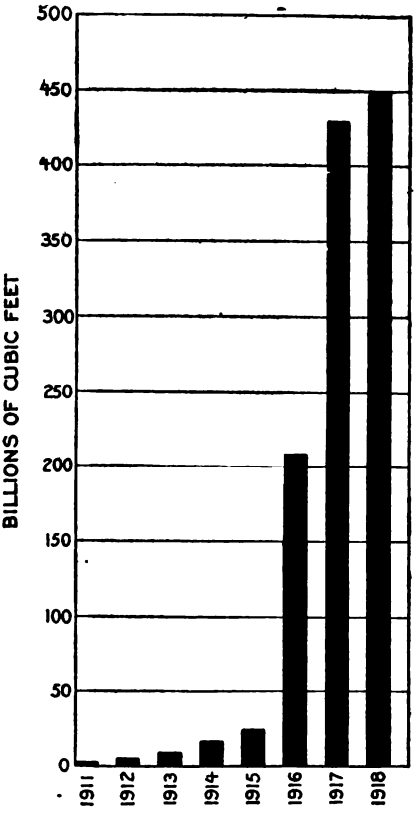

FIGURE 122.—Estimated volume of natural gas treated in the manufacture of natural-gas gasoline, 1911–1918.

The raw natural-gas gasoline produced in the United States in 1918 was extracted from about 449,108,661,000 cubic feet of gas, an increase in the volume of gas treated of 4.6 per cent, as compared with that in 1917 (fig. 122).

The total number of plants producing natural-gas gasoline in 1918 was 1,004, an increase of 118, or 13.3 per cent, over the number in 1917 (fig. 121).

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In 1918 natural-gas gasoline was made in the United States by 503 operators.

STATISTICS OF NATURAL-GAS GASOLINE.

Natural-gas gasoline produced in the United States, 1911–1918.

Year.	Number of operators.	Plants.		Gasoline produced.			Gas used.		
		Number.	Daily capacity.	Quantity.	Value.	Price per gallon.	Estimated volume.	Value.	Average yield of gasoline per thousand cubic feet.
			Gallons.	*Gallons.*		*Cents.*	*M cu. ft.*		*Gallons.*
1911	132	176	37,100	7,425,839	$531,704	7.16	2,475,697	$176,961	3.00
1912	186	250	61,268	12,081,179	1,157,476	9.6	4,687,796	331,985	2.6
1913	232	341	152,415	24,060,817	2,458,443	10.22	9,889,442	566,224	2.43
1914	254	386	179,353	42,652,632	3,105,909	7.28	16,894,557	889,906	2.43
1915	287	414	232,336	65,364,665	5,150,823	7.88	24,064,391	1,202,555	2.57
1916	460	596	495,448	103,492,689	14,331,148	13.85	208,705,028	[a] 14,609,351	.496
1917	750	886	902,385	217,884,104	40,188,956	18.45	429,287,797	[a] 34,343,024	.508
1918	[b]503	1,004	[a] 1,022,072	282,535,550	50,363,535	17.8	449,108,061	[a] 40,419,779	.63

[a] Estimated.

[b] This number is irrespective of the kind, number, and location of the plants operated. The sum of the number of operators listed for each method employed and for each county and State will therefore not give the correct number of operators in the United States. A comparison of the number of operators in 1918 with the number in prior years can not be made because they have not been listed in the same way for those years.

Natural-gas gasoline produced in the United States in 1918.

[Includes only unblended gasoline.]

State.	Number of operators.	Number of plants.	Gasoline produced.			Gas used.	
			Quantity.	Value.	Average price per gallon.	Estimated volume.	Average yield of gasoline per thousand cubic feet.
			Gallons.		*Cents.*	*M cu. ft.*	*Gallons.*
Oklahoma	133	276	163,700,550	$28,389,045	17.3	78,322,397	2.09
West Virginia	79	208	37,603,903	7,498,804	19.9	163,929,550	.23
California	29	56	32,268,933	5,009,152	15.5	50,490,019	.64
Pennsylvania	200	282	15,775,058	3,249,233	20.6	56,982,053	.28
Texas	8	13	7,326,122	1,214,565	16.6	8,493,182	.86
Louisiana	9	18	7,020,538	1,178,651	16.8	13,462,317	.52
Ohio	36	55	6,744,907	1,355,447	20.1	37,739,322	.18
Illinois	34	72	4,574,565	890,436	19.5	2,316,646	1.97
Kentucky	5	6	3,330,986	660,108	19.8	19,816,518	.17
Kansas	5	11	2,389,856	593,730	24.8	16,023,067	.15
Wyoming	2	3	1,579,596	268,389	17.0	1,433,564	1.10
New York	5	4	218,131	55,405	25.4	99,487	2.19
Colorado			2,475	620	25.1	619	4.00
United States, 1918	[a] 503	1,004	282,535,550	50,363,535	17.8	449,108,661	.63
United States, 1917	750	886	217,884,104	40,188,956	18.45	429,287,797	.508

[a] This number is irrespective of the kind, number, and location of the plants operated. The sum of the number of operators listed for each method employed and for each county and State will therefore not give the correct number of operators in the United States. A comparison of the number of operators in 1918 with the number in prior years can not be made because they have not been listed in the same way for those years.

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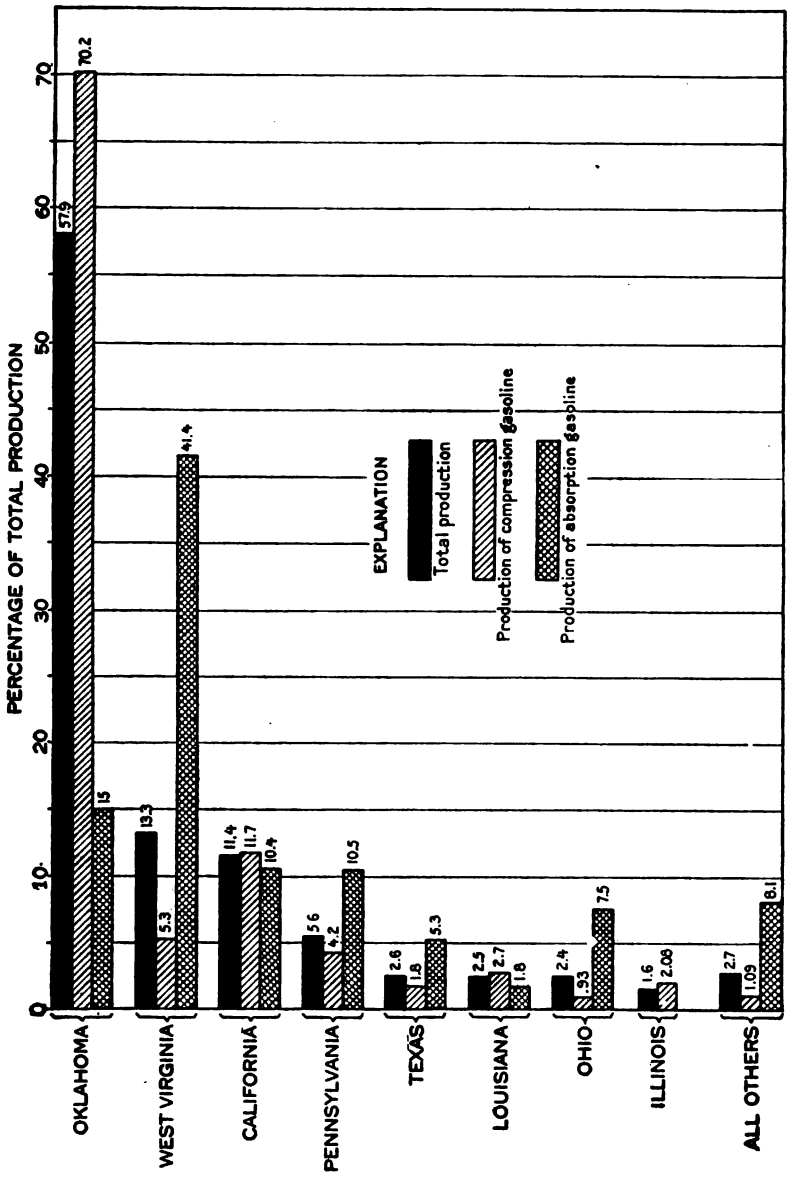

FIGURE 123.—Natural-gas gasoline produced in the United States, by States, in 1918.

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Natural-gas gasoline produced in the United States in 1918—Continued.

State.	Percentage of total production of State.		Percentage of total production of United States.		
	Compression.	Absorption.	Compression.	Absorption.	Total
Oklahoma	94.2	5.8	70.2	15.0	57.9
West Virginia	30.9	69.1	5.3	41.4	13.3
California	79.9	20.1	11.7	10.4	11.4
Pennsylvania	58.1	41.9	4.2	10.5	5.6
Texas	54.9	45.1	1.8	5.3	2.6
Louisiana	84.1	15.9	2.7	1.8	2.5
Ohio	30.2	69.8	.93	7.5	2.4
Illinois	100.0	.....	2.08	.....	1.6
Kentucky	2.9	97.1	.04	5.2	1.2
Kansas	33.6	66.4	.36	2.5	.8
Wyoming	82.7	17.3	.59	.4	.6
New York	96.8	3.2	.1	.....	.1
Colorado	100.0	.....			
United States, 1918	77.8	22.2	100.00	100.0	100.0
United States, 1917	77.5	22.5	100.00	100.0	100.0

Classification of natural-gas gasoline by principal methods of manufacture, 1916–1918.

1916.

Gasoline produced by compression and by vacuum pumps.

State.	Plants.		Gasoline produced.			Gas used.	
	Number.	Daily capacity.	Quantity.	Value.	Price per gallon.	Estimated volume.	Average yield in gasoline per thousand cubic feet.
		Gallons.	*Gallons.*		*Cents.*	*M cubic feet.*	*Gallons.*
Oklahoma	104	215,377	45,827,325	$5,471,307	11.94	14,018,757	3.269
West Virginia	133	39,276	9,289,624	1,642,031	17.67	3,550,523	2.616
Pennsylvania	185	30,287	6,722,370	1,216,717	18.10	2,693,215	2.496
Louisiana	7	10,661	2,113,159	269,564	12.76	907,153	2.329
Texas	4	6,688	1,292,811	201,023	15.55	948,485	1.363
New York	5	1,025	249,055	40,283	16.17	102,819	2.422
Colorado	1						
California	24						
Ohio	53						
Illinois	29	72,251	19,428,443	2,652,776	13.65	14,492,463	1.45
Kentucky	3						
Kansas	2						
	550	375,565	84,922,787	11,493,701	13.53	36,713,415	.....

Gasoline produced by absorption.[a]

West Virginia	14	59,383	9,475,432	$1,383,262	14.60	101,114,013	0.094
Pennsylvania	10	16,200	2,992,556	509,456	17.02	35,797,406	.084
Oklahoma	12	17,700	2,532,277	393,838	15.55	10,730,697	.236
California	2						
Kentucky	2						
Illinois	3	26,600	3,569,637	550,891	15.43	24,349,492	.145
Ohio	2						
Kansas	1						
	46	119,883	18,569,902	2,837,447	15.28	171,991,608	.....
Grand total	596	495,448	103,492,689	14,331,148	13.85	208,705,023	.496

[a] Includes drip gasoline.

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Classification of natural-gas gasoline by principal methods of manufacture, 1916–1918—Continued.

1917.

Gasoline produced by compression and by vacuum pumps.

State.	Plants.		Gasoline produced.			Gas used.	
	Number.	Daily capacity.	Quantity.	Value.	Price per gallon.	Estimated volume.	Average yield in gasoline per thousand cubic feet.
		Gallons.	*Gallons.*		*Cents.*	*M cubic feet.*	*Gallons.*
Oklahoma	207	456,632	108,728,213	$20,321,067	18.68	36,399,280	2.987
California	40	82,092	23,478,521	3,637,827	15.49	27,477,443	.854
West Virginia	150	44,348	12,276,784	2,211,494	18.01	4,845,648	2.534
Pennsylvania	234	32,564	9,011,199	1,792,430	19.89	3,572,356	2.522
Louisiana	18	17,915	4,459,920	719,758	16.14	1,558,346	2.862
Illinois	54	15,392	4,268,158	756,344	17.72	2,020,044	2.113
Texas	8	10,900	3,942,337	664,543	16.86	2,666,983	1.478
Ohio	54	8,337	2,331,498	423,106	18.15	836,639	2.787
New York	5						
Kansas	1						
Kentucky	3	3,322	369,925	70,361	19.02	150,784	2.453
Colorado	1						
	784	671,502	168,866,555	30,596,930	18.12	79,527,523	2.123

Gasoline produced by absorption.

West Virginia	29	91,315	20,391,863	$4,300,319	21.09	162,925,703	0.126
Oklahoma	27	35,804	6,395,211	1,220,538	19.09	48,320,061	.132
California	9	17,669	5,339,083	800,195	14.99	17,873,804	.299
Pennsylvania	17	26,600	4,815,051	985,068	20.47	45,914,700	.105
Kentucky [a]	2	[b] 13,000	3,725,893	745,210	20.00	24,871,590	.150
Ohio	7	16,800	3,108,062	628,270	20.21	29,225,502	.106
Texas [c]	3	21,650	2,978,068	484,898	16.28	10,010,233	.298
Kansas	5	3,842	1,071,633	220,550	20.58	9,274,289	.116
Illinois [a]	1	2,000	665,851	109,689	16.47	665,851	1.000
Louisiana [a]	2	2,203	519,834	94,989	18.27	675,165	.770
New York [d]	.....	.....	7,000	1,400	20.00	2,776	.....
	102	230,883	49,017,549	9,592,026	19.57	349,760,274	.140
Grand total	886	902,385	217,884,104	40,188,956	18.45	429,287,797	.508

[a] Includes drip gasoline.
[b] Includes gasoline produced in Kentucky from West Virginia gas.
[c] Includes some gasoline produced by compression.
[d] Drip gasoline only.

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Classification of natural-gas gasoline by principal methods of manufacture, 1916–1918—Continued.

1918.

Gasoline produced by compression and by vacuum pumps.

State.	Number of plants.	Gasoline produced.			Gas used.	
		Quantity.	Value.	Average price per gallon.	Estimated volume.	Average yield of gasoline per thousand cubic feet.
		Gallons.		*Cents.*	*M cubic ft.*	*Gallons.*
Oklahoma	238	154,271,605	$26,521,398	17.2	46,684,983	3.30
California	39	25,767,346	3,906,355	15.2	33,162,732	.78
West Virginia	172	11,612,114	2,191,367	18.9	5,218,740	2.23
Pennsylvania	259	9,158,795	1,793,334	19.6	3,937,123	2.33
Louisiana	15	5,903,723	847,509	14.4	1,906,837	3.10
Illinois	72	4,574,565	890,436	19.5	2,316,646	1.97
Texas	9	4,024,398	618,941	15.4	1,575,010	2.56
Ohio	45	2,035,406	395,626	19.4	710,356	2.87
Wyoming	2	1,306,063	211,220	16.2	613,175	2.13
Kansas	6	802,773	200,693	25.0	3,626,789	.22
New York	3	211,131	54,006	25.6	96,711	2.18
Kentucky	4	98,788	13,754	13.6	48,426	2.01
Colorado	1			25.1		4.00
	865	219,767,207	37,644,649	17.1	99,897,528	2.20

Gasoline produced by absorption.[a]

West Virginia	36	25,991,789	$5,307,437	20.4	158,710,810	0.16
Oklahoma	38	9,428,945	1,867,647	19.8	31,637,324	.30
Pennsylvania	23	6,616,263	1,455,899	22.0	53,044,940	.12
California	17	6,501,587	1,102,797	17.0	17,327,287	.38
Ohio	10	4,709,501	959,821	20.4	37,028,966	.13
Texas	4	3,301,224	595,624	18.0	6,918,172	.48
Kentucky	2	3,234,673	646,973	20.0	19,768,711	.16
Kansas	5	1,587,083	393,037	24.8	12,396,278	.13
Louisiana	3	1,116,315	331,142	29.7	11,555,480	.10
Wyoming	1	280,463	58,509	20.9	823,165	.33
New York[b]				20.0		2.52
	139	62,768,343	12,718,886	20.3	349,211,133	.18
Grand total, 1918	1,004	282,535,550	50,363,535	17.8	449,108,661	.63

[a] Includes drip gasoline. [b] Drip gasoline only.

Commercial gasoline produced by the blending of natural-gas gasoline in 1918.

State.	Quantity.	Value.
	Gallons.	
Oklahoma	215,857,434	$43,194,180
West Virginia	14,343,121	2,858,279
Pennsylvania	9,873,707	1,998,418
Texas	5,912,665	979,162
Kentucky	3,600,027	722,585
Kansas	3,134,509	678,970
Wyoming	2,519,052	407,406
California	2,464,812	447,962
Ohio	1,611,739	358,788
Illinois	1,540,516	247,290
Louisiana	1,161,685	194,564
New York	592,000	75,529
United States	262,611,267	52,163,133

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NATURAL-GAS GASOLINE INDUSTRY, BY STATES.

CALIFORNIA.

California retained its place as third in rank among the States producing natural-gas gasoline in 1918; the output amounted to 32,268,933 gallons, valued at $5,009,152. This was the greatest production ever credited to the State in any one year, the increase over 1917 being 3,451,329 gallons, or 12 per cent. The output for the State was 11.4 per cent of the total for the United States.

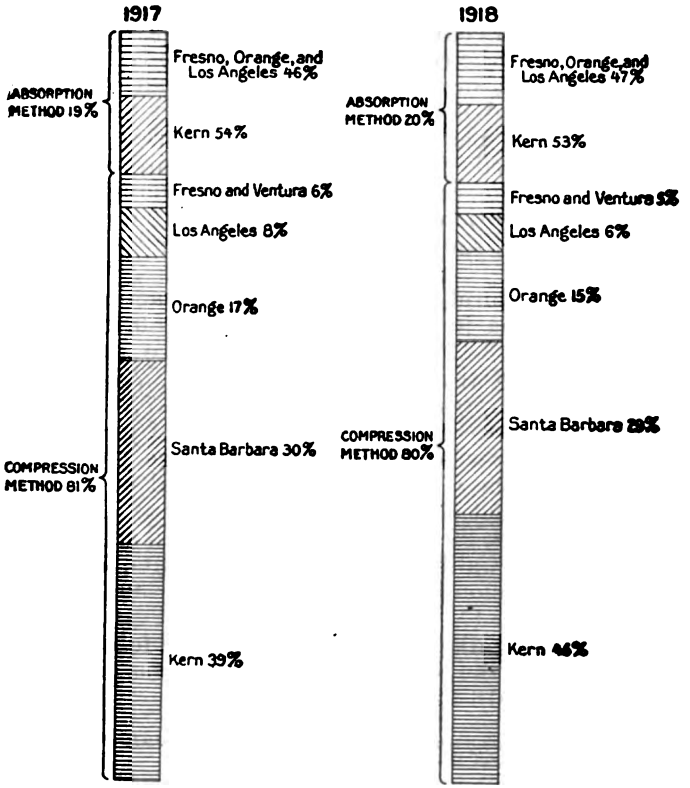

FIGURE 124.—Natural-gas gasoline produced in California in 1917 and 1918, by principal methods of manufacture and by counties.

Of the total quantity of gasoline produced in the State in 1918, 25,767,346 gallons, or 80 per cent, was produced by the compression method and 6,501,587 gallons, or 20 per cent, by the absorption process. The counties producing the gasoline by the compression method were Kern, 45 per cent; Santa Barbara, 29 per cent; Orange, 15 per cent; Los Angeles, 6 per cent; and Ventura and Fresno, 5 per cent. Only four counties have absorption plants; Kern ranked first with 53 per cent, and Los Angeles, Fresno, and Orange produced 47 per cent. There was an increase in production by both methods over 1917. California ranked second in the quantity of gasoline produced by the compression method, producing 11.7 per cent of

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the total compression product in the United States in 1918, and fourth in the quantity of gasoline extracted at the absorption plants and obtained as drip from the mains, its output being 10.4 per cent of the total absorption product in the United States.

The average daily output of natural-gas gasoline in California in 1918 was 88,408 gallons, an increase of 9,456 gallons as compared with 1917. The quantity of commercial gasoline produced from the blending of the raw gasoline recovered from natural gas in California in 1918 probably amounted to 2,464,812 gallons, valued at $447,962.

The market value at the sources of production of the total output of raw gasoline in California in 1918 was $5,009,152, an increase of $571,130, or 12.9 per cent, as compared with the value in 1917. Of this combined value the compression product contributed $3,906,355, which was $268,528, or 7.4 per cent, more than in 1917; and the absorption plant and drip gasoline contributed $1,102,797, a gain of $302,602, or 37.8 per cent. The average price received for the raw gasoline produced was 15.5 cents per gallon, an increase of 0.1 cent over 1917. The compression gasoline averaged 15.2 cents a gallon and the absorption product averaged 17 cents a gallon, which, compared with 1917, show a loss of 0.3 cent and a gain of 2 cents, respectively.

The volume of natural gas treated in the extraction of natural-gas gasoline in California in 1918 is estimated at 50,490,019,000 cubic feet, which was 5,138,772,000 cubic feet more than the volume treated in 1917. Of this total volume, 33,162,732,000 cubic feet was used in the compression process and 17,327,287,000 cubic feet in the absorption process. The average yield of gasoline per thousand cubic feet of gas was 0.64 gallon; the average yield for the compression product was 0.78 gallon per thousand cubic feet and for the absorption product 0.38 gallon.

At the end of 1918, 29 operators were engaged in the natural-gas gasoline industry in California and used 56 plants, 7 of which were new. The compression process was used in 39 plants and the absorption process in 17.

The accompanying diagram (fig. 124) and the following statistical tables show in detail the progress of the natural-gas gasoline industry in California from 1916 to 1918.

Natural-gas gasoline produced in California, 1916–1918.

1916.

County.	Number of operators.	Plants.		Gasoline produced.		Estimated volume of gas treated.	Range in yield of gasoline per M cubic feet of gas.	Range in gravity of gasoline as produced and before blending.
		Number.	Daily capacity.	Quantity.	Value.			
			Gallons.	*Gallons.*		*M cubic feet.*	*Gallons.*	*°Baumé.*
Santa Barbara	6	7	21,642	7,462,566	$1,046,308	4,806,583	1.0 –2.5	72–81
Kern	8	5	10,488	[a] 3,353,428	483,729	11,916,940	.025–1.0	60–75
Orange	7	7	12,700	[b] 3,026,652	368,785	2,592,613	.5 –3.0	67–81
Los Angeles	5	4	4,330	1,155,758	146,850	1,951,101	.3 –2.0	65–80
Ventura	1	1	4,900	[c] 2,160,340	248,150	3,559,117	[d] 1.84	[d] 85.3
Fresno	1	2					.3 –1.2	63–75
	28	26	54,060	17,158,754	2,293,822	24,826,354	[d] .691	60–85.3

[a] Includes drip gasoline.
[b] Includes gasoline made by the absorption process at one plant.
[c] Includes Los Angeles County drips and gasoline made by absorption process at one plant in Fresno County.
[d] Average.

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Natural-gas gasoline produced in California, 1916–1918—Continued.

1917.

Gasoline produced by compression and by vacuum pumps.

County.	Number of operators.	Plants. Number.	Plants. Daily capacity.	Gasoline produced. Quantity.	Gasoline produced. Value.	Estimated volume of gas treated.	Range in yield of gasoline per M cubic feet of gas.	Range in gravity of gasoline as produced and before blending.
			Gallons.	*Gallons.*		*M cubic feet.*	*Gallons.*	*°Baumé.*
Kern	9	13	26,773	9,165,898	$1,351,568	10,552,967	0.5 –1.8	64–79
Santa Barbara	6	8	30,429	7,056,616	1,129,813	4,485,648	1.0 –2.3	73–82
Orange	7	7	12,200	4,067,575	649,506	4,171,338	.17–3.0	65–81
Los Angeles	6	7	7,200	1,827,515	297,833	7,237,470	.11–2.0	62–80
Ventura	3	3	3,350	1,360,917	209,047	1,030,020	1.15–1.5	71.2–85
Fresno	2	2	2,140					
	33	40	82,092	23,478,521	3,637,827	27,477,443	[a].854	62–85

Gasoline produced by absorption.[b]

Kern	8	5	9,969	2,893,684	$416,429	13,090,177	0.02–1.07	45–70
Los Angeles	1	1						
Orange	2	2	7,700	2,445,399	383,766	4,783,627	.50– .58	50–68
Fresno	1	1						
	12	9	17,669	5,339,083	800,195	17,873,804	[a].2987	45–70
Grand total	45	49	99,761	28,817,604	4,438,022	45,351,247	[a].635	45–85

[a] Average. [b] Includes drip gasoline.

1918.

Gasoline produced by compression and by vacuum pumps.

County.	Number of operators.[a]	Number of plants.	Gasoline produced. Quantity.	Gasoline produced. Value.	Estimated volume of gas treated.	Range in yield of gasoline per thousand cubic feet of gas.	Range in gravity of gasoline as produced and before blending.
			Gallons.		*M cu. ft.*	*Gallons.*	*°Baumé.*
Kern	9	13	11,517,906	$1,738,066	14,891,343	0.5 –1.25	66–77.5
Santa Barbara	5	8	7,354,082	1,073,664	4,428,075	1.5 –2.41	72–77
Orange	6	6	3,998,931	625,881	10,952,745	.11–3.0	64–79
Los Angeles	6	8	1,565,213	258,131	1,813,436	.5 –2.0	62–80
Ventura	2	2	899,208	150,599	587,008	1.12–1.62	78–82
Fresno	2	2	432,006	60,014	490,125	.72–1.5	67–71
	[a]25	39	25,767,346	3,906,355	33,162,732	[b].78	62–82

Gasoline produced by absorption.[c]

Kern	7	11	3,511,369	$537,199	8,661,653	0.1–1.0	47–69
Los Angeles	1	1	2,321,091	461,367	7,565,271	.29	40–60
Fresno	1	1				.64	69
Orange	3	4	669,127	104,231	1,100,383	.5–2.26	68–81
	[a]10	17	6,501,587	1,102,797	17,327,287	[b].38	40–81
Grand total	[a]29	56	32,268,933	5,009,152	50,490,019	[b].64	40–82

[a] This number is irrespective of the kind, number, and location of the plants operated. The sum of the number of operators listed for each method employed and for each county will therefore not give the correct number of operators in the State. A comparison with the number of operators for prior years can not be made because thay have not been listed in the same way.
[b] Average.
[c] Includes drip gasoline.

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COLORADO.

The 2,475 gallons of natural-gas gasoline produced in Colorado in 1918 was obtained from 1 compression plant in Boulder County. The total value of this output was about $620. The gas used was the casing-head gas from oil wells in the old Boulder oil field.

ILLINOIS.

Illinois experienced a decline in the natural-gas gasoline industry in 1918, the production decreasing 359,444 gallons, or 7.3 per cent, as compared with 1917. The total output for 1918 was 4,574,565 gallons, or 1.6 per cent of the total production in the United States. The average daily production in the State in 1918 was 12,533 gallons.

The market value of the gasoline sold was $890,436, an increase of $24,403, or 2.8 per cent, over the value in 1917, and the average price received at the point of production was 19.5 cents a gallon.

The total quantity of gas treated for gasoline extraction in 1918 was 2,316,646,000 cubic feet, or 369,249,000 cubic feet less than in the preceding year. The average yield of gasoline per thousand cubic feet of gas in 1918 was 1.97 gallons. The total quantity of commercial gasoline produced as a result of blending at the plants aggregated 1,540,516 gallons, with a market value of $247,290.

The natural-gas gasoline industry in Illinois is in Lawrence, Crawford, and Clark counties, in the eastern part of the State. The gas treated for the manufacture of gasoline was casing-head gas from oil wells, and the gasoline was extracted chiefly by the compression process. The exhaust gas was utilized mostly on the leases for pumping and drilling, and only a small proportion was sent through the pipe lines for distribution.

In 1918 there were 34 operators engaged in the natural-gas gasoline industry in Illinois. During the year 17 plants were completed, compared with 23 plants in 1917. There were 72 plants in operation, compared with 55 plants in 1917.

Natural-gas gasoline produced in Illinois, 1916–1918.

1916.

County.	Number of operators.	Plants.		Gasoline produced.		Estimated volume of gas treated.	Range in yield of gasoline per thousand cubic feet of gas.	Range in gravity of gasoline as produced and before blending.
		Number.	Daily capacity.	Quantity.	Value.			
			Gallons.	*Gallons.*		*M cubic feet.*	*Gallons.*	*°Baumé.*
Lawrence [a]	8	22	9,300	1,928,974	$328,773	1,196,615	1.0–2.5	70–87
Crawford	8	10	2,770	331,314	38,891	141,979	1.5–4.0	69–88
Clark	1							
	17	32	12,070	2,260,288	262,664	1,338,594	[b] 1.688	69–88

1917.

Lawrence [c]	10	27	10,762	3,529,712	$612,080	2,047,946	0.5–3.0	65–100
Crawford [d]	23	28	6,630	1,404,297	253,953	637,949	1.11–4.5	65–94
Clark								
	33	55	17,392	4,934,009	866,033	2,685,895	[b] 1.837	65–100

[a] Includes statistics of one operator that used absorption method.
[b] Average.
[c] Includes statistics of one operator that used absorption method and one that produced drip.
[d] Includes statistics of drip gasoline produced by six operators.

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Natural-gas gasoline produced in Illinois, 1916–1918—Continued.

1918.

County.	Number of operators.[a]	Number of plants.	Gasoline produced. Quantity.	Gasoline produced. Value.	Estimated volume of gas treated.	Range in yield of gasoline per thousand cubic feet of gas.	Range in gravity of gasoline as produced and before blending.
			Gallons.		*M cubic feet.*	*Gallons.*	*°Baumé.*
Lawrence	11	25	2,505,393	$492,960	1,144,945	1.0–3.5	72–86
Crawford	25	44	2,045,200	392,308	1,150,908	1.0–4.0	68–85
Clark	3	3	23,472	4,668	11,793	1.5–2.0	65–84
	[a] 34	72	4,574,565	890,436	2,316,646	1.0–4.0	65–86

[a] This number is irrespective of the kind, number, and location of the plants operated. The sum of the number of operators listed for each method employed and for each county will therefore not give the correct number of operators in the State. A comparison with the number of operators for prior years can not be made because they have not been listed in the same way.

KANSAS.

Kansas showed an increase of 103 per cent in the production of natural-gas gasoline in 1918, as compared with a gain of 447 per cent in 1917. The total production in the State amounted to 2,389,856 gallons, of which 802,773 gallons, or 33.6 per cent, was produced by compression and vacuum-pump methods and 1,587,083 gallons, or 66.4 per cent, by absorption method and drip. The compression product was 0.36 per cent of the total quantity of gasoline produced by such plants in the United States in 1918, and the absorption process and drip supplied 2.5 per cent of the total output from these sources in the United States in 1918. The combined production in the State was 0.8 per cent of the total output in the United States. The average daily production in 1918 was 6,548 gallons.

The total market value of the raw gasoline in the State in 1918 was $593,730, of which $200,693 was attributed to the compression gasoline and $393,037 to the absorption and drip product. The gain in the total value in 1918 was $352,511. The average price increased from 20.53 cents to 24.8 cents a gallon in 1918.

Because of its high gravity test some of the raw gasoline was blended at the plants, and as a result 3,134,509 gallons of commercial gasoline, valued at $678,970, was produced.

The total quantity of gas consumed in the manufacture of gasoline in the State in 1918 was estimated at 16,023,067,000 cubic feet, an increase of 6,707,728 cubic feet over 1917.

The average yield of gasoline per thousand cubic feet of the gas utilized in 1918 was approximately 0.15 gallon, or a little more than the average yield in 1917. The gas, after the extraction of the gasoline, was either returned to the lessees or sold for domestic and industrial consumption.

At the end of 1918 there were 11 gasoline plants in operation in Kansas, of which 6 were compression plants and 5 were absorption plants, which were distributed through Butler, Chautauqua, Cowley, Montgomery, and Wilson counties. There were 5 operators engaged in the industry.

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Natural-gas gasoline produced in Kansas in 1918.

Gasoline produced by compression and by vacuum pumps.

County.	Number of operators.[a]	Number of plants.	Gasoline produced. Quantity.	Gasoline produced. Value.	Estimated volume of gas treated.	Range in yield of gasoline per thousand cubic feet of gas.	Range in gravity of gasoline as produced and before blending.
			Gallons.		*M cu. ft.*	*Gallons.*	°*Baumé.*
Cowley	1	2	504,523	$126,131	3,500,997	0.13–0.165	86–90
Montgomery	1	1				.10	86–90
Chatauqua	2	3	298,250	74,562	125,792	2.25–3.0	78–85
	4	6	802,773	200,393	3,626,789	.10–3.0	78–90

Gasoline produced by absorption.

Cowley	1	2	1,587,083	$393,037	12,396,278	0.13–0.16	64–76
Montgomery	2	1				.15	72
Wilson	1	1				.75	.....
Butler	1	1				.31	76
	[a] 3	5	1,587,083	393,037	12,396,278	.13– .75	64–76
Grand total	[a] 5	11	2,389,856	593,730	16,023,067	.10–3.0	64–90

[a] This number is irrespective of the kind, number, and location of the plants operated. The sum of the number of operators listed for each method employed and for each county will therefore not give the correct number of operators in the State. A comparison with the number of operators for prior years can not be made because they have not been listed in the same way.

KENTUCKY.

Although the total production of natural-gas gasoline in Kentucky in 1918 was 3,330,986 gallons, 487,223 gallons less than in 1917, or a loss of 12.8 per cent, the State retained ninth rank among the producing States. The absorption plants produced 3,231,673 gallons and the compression plants 96,313 gallons. The product of the absorption plants and the drip gasoline constituted 5.2 per cent of the output of gasoline from these sources in the United States in 1918, and the output of the compression plants amounted to 0.04 per cent of the total. The combined output for Kentucky in 1918 was 1.2 per cent of the total production in the United States in that year. The average daily production in 1918 was 9,126 gallons.

It is estimated that 3,600,027 gallons of commercial gasoline, having an estimated value of $722,585, was produced by blending the raw gasoline in the State in 1918.

The average price received for the raw gasoline at the source of production in 1918 was 19.8 cents a gallon, and the market value of the entire output in the State was $660,108, a loss of 0.2 cent in average unit selling price and of $103,078, or 13.5 per cent, in total market value, as compared with 1917. The absorption gasoline, including the drip gasoline, was valued at $646,973, and the gasoline obtained at the compression plants at $13,135.

The volume of natural gas utilized in the extraction of the raw gasoline by the combined methods in 1918 was 19,816,518,000 cubic

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feet. The absorption process consumed 19,768,711,000 cubic feet, or 99.8 per cent of all the gas used, and the compression method consumed 47,807,000 cubic feet. The natural gas was either produced by the operators themselves or purchased and, after the extraction of the gasoline, was used on the leases, sold to distributing companies, or forced back into the wells.

Six plants produced raw gasoline in the State in 1918, of which 4 were compression plants and 2 were absorption plants. The compression plants are in Morgan and Wayne counties and the absorption plants in Boyd and Martin counties. A small quantity of drip gasoline was recovered in Menifee County. The plants in 1918 were run by 5 operators.

Natural-gas gasoline produced in Kentucky in 1918.

Gasoline produced by compression and by vacuum pumps.

County.	Number of operators.[a]	Number of plants.	Gasoline produced. Quantity.	Gasoline produced. Value.	Estimated volume of gas treated.	Range in yield of gasoline per thousand cubic feet of gas.	Range in gravity of gasoline as produced and before blending.
			Gallons.		*M cu. ft.*	*Gallons.*	°*Baumé.*
Wayne	3	3	96,313	$13,135	47,807	[b] 2.0	[b] 80
Morgan	1	1				1.7–3.5	78
	4	4	96,313	13,135	47,807	1.7–3.5	78–80

Gasoline produced by absorption.[c]

Boyd	1	1	3,234,673	$646,973	19,768,711	0.15	86
Martin	1	1				.22	88
	[a] 1	2	3,234,673	646,973	19,768,711	.15–.22	86–88
Grand total	[a] 5	6	3,330,986	660,108	19,816,518	[b] .16	78–88

[a] This number is irrespective of the kind, number, and location of the plants operated. The sum of the number of operators listed for each method employed and for each county will therefore not give the correct number of operators in the State. A comparison with the number of operators for prior years can not be made because they have not been listed in the same way.
[b] Average.
[c] Includes drip gasoline recovered in Menifee County.

LOUISIANA.

A production of 7,020,538 gallons of raw gasoline in 1918, a gain of 2,040,784 gallons, or 41 per cent, over the production in 1917, enabled Louisiana to move from seventh to sixth place among the States producing natural-gas gasoline. This output was 2.5 per cent of the total production in the United States. The compression plants contributed 5,903,723 gallons, or 84 per cent of the output, an increase of 32.4 per cent over the like product in 1917, and 2.7 per cent of the total gasoline produced in such plants in the United States in 1918. The remaining 1,116,815 gallons, or 16 per cent of the output of the State in 1918, was produced by the absorption process and the drips from gas mains and was an increase of 115 per cent over the quantity similarly produced in 1917, and 1.8 per cent of the

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total output from these sources in the country in 1918. The average daily output of raw gasoline in Louisiana during 1918 was 19,234 gallons.

In the extraction of the gasoline 1,906,837,000 cubic feet of gas was treated at the compression plants and 11,555,480,000 cubic feet at the absorption plants, a total of 13,462,317,000 cubic feet for the year, which was a gain of 503 per cent over the quantity treated in 1917. The average recovery of gasoline per thousand cubic feet was 0.52 gallon by all methods, 3.1 gallons by the compression method, and 0.1 gallon by the absorption process and drip.

The total market value of the gasoline output for the State in 1918 amounted to $1,178,651, an increase of 44.7 per cent, as compared with 1917. Of this value, $847,509 was credited to the gasoline extracted by the compression method and $331,142 to that produced by the absorption method and salvaged as drip from gas mains. Compression gasoline showed an increase of 17.7 per cent and absorption gasoline of 249 per cent over the values for the gasoline produced by these respective processes in 1917. The average price received during 1918 for the raw gasoline at the sources of production was 16.8 cents a gallon, for the compression product 14.4 cents, and for the absorption and drip products 29.7 cents a gallon.

The quantity of commercial gasoline obtained by blending the raw gasoline was estimated at 1,161,685 gallons, valued at $194,564.

The quantity of gasoline reported to the Geological Survey was the product of 15 compression plants and 3 absorption plants, 2 less than the 20 plants operating in 1917. The compression plants are in Caddo and De Soto parishes, and the absorption plants in Caddo Parish alone. There were 9 operators engaged in the gasoline industry in 1918.

Natural-gas gasoline produced in Louisiana, 1916–1918.

Parish.	Number of operators.	Plants.		Gasoline produced.		Estimated volume of gas treated.	Range in yield of gasoline per thousand cubic feet of gas.	Range in gravity of gasoline as produced and before blending.
		Number.	Daily capacity.	Quantity.	Value.			
1916.								
			Gallons.	*Gallons.*		*M cubic feet.*	*Gallons.*	*° Baumé.*
Caddo	4	4	8,006	1,803,151	$227,067	813,750	1.5–3.3	64–80
De Soto	3	3	2,655	310,008	42,497	93,403	3.0–4.0	76–78
	7	7	10,661	2,113,159	269,564	907,153	[a]2.329	64–80
1917.								
Caddo	8	12	13,950	3,447,424	$559,891	1,252,297	1.10–4.69	68–80
De Soto	4	6	3,965	1,012,496	159,867	306,049	2.05–4.69	72–78
Total by compression and vacuum	12	18	17,915	4,459,920	719,758	1,558,346	[a]2.862	68–80
Total by absorption [b]	3	2	2,203	519,834	94,989	675,165	a.77	69–92
Grand total	15	20	20,118	4,979,754	814,747	2,233,511	[a]2.229	68–92

[a] Average.

[b] Includes drip gasoline.

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Natural-gas gasoline produced in Louisiana, 1916–1918—Continued.

1918.

Gasoline produced by compression and by vacuum pumps.

Parish.	Number of operators.[a]	Number of plants.	Gasoline produced.		Estimated volume of gas treated.	Range in yield of gasoline per thousand cubic feet of gas.	Range in gravity of gasoline as produced and before blending.
			Quantity.	Value.			
			Gallons.		*M cu. ft.*	*Gallons.*	[b] *Baumé.*
Caddo	6	9	4,726,132	$673,630	1,518,402	1.51–4.0	60–80.4
De Soto	4	6	1,177,591	173,879	388,435	2.15–6.0	72–80.0
	[a] 7	15	5,903,723	847,509	1,906,837	[b] 3.10	60–80.4

Gasoline produced by absorption.[c]

Caddo	3	3	1,116,815	$331,142	11,555,480	[b] 0.10	69–82
Grand total	[a] 9	18	7,020,538	1,178,651	13,462,317	[b] .52	60–82

[a] This number is irrespective of the kind, number, and location of the plants operated. The sum of the number of operators listed for each method employed and for each parish will therefore not give the correct number of operators in the State. A comparison with the number of operators for prior years can not be made because they have not been listed in the same way.
[b] Average.
[c] Includes drip gasoline.

NEW YORK.

New York produced 218,131 gallons of natural-gas gasoline in 1918. Of this total output 211,131 gallons was produced by the compression method, and the remaining 7,000 gallons was salvaged from gas mains as drip gasoline. The average daily production was 598 gallons.

It is estimated that in New York 592,000 gallons of commercial gasoline, valued at $75,529, was obtained as a result of blending the raw gasoline.

The value of the total output of raw gasoline in New York in 1918 was estimated at $55,405, which was an average price of 25.4 cents a gallon.

The volume of natural gas treated, as far as can be ascertained, was probably 99,487,000 cubic feet, and the average yield of raw gasoline per thousand cubic feet of gas was 2.19 gallons.

The total output was obtained from three compression plants and from gasoline salvaged as drip from transmission lines. The operations were conducted by four operators.

OHIO.

Ohio produced 6,744,907 gallons of natural-gas gasoline in 1918, 1,305,347 gallons more than in 1917, or an increase of 24 per cent. The State dropped from sixth to seventh place in 1918. Compression plants contributed 2,035,406 gallons, or 30.2 per cent of the State's output, and absorption plants 4,709,501 gallons, or 69.8 per cent. Ohio contributed 0.93 per cent of all the compression gasoline recovered in the United States in 1918 and 7.5 per cent of all the gasoline produced by the absorption method and salvaged as drip. The total State output was 2.4 per cent of the total quantity of natural-gas gasoline produced in the United States in 1918.

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The average daily production in Ohio in 1918 was 18,479 gallons, as compared with 14,903 gallons in 1917. The quantity of commercial gasoline produced from the raw gasoline in 1918 was approximately 1,611,739 gallons, having an estimated value of $358,788.

The average price received for the gasoline in 1918 was 20.1 cents a gallon, a rise of 0.77 cent a gallon over the price received in 1917. The average price for the compression-plant product was 19.4 cents a gallon, an increase of 1.29 cents; the average price for the absorp-

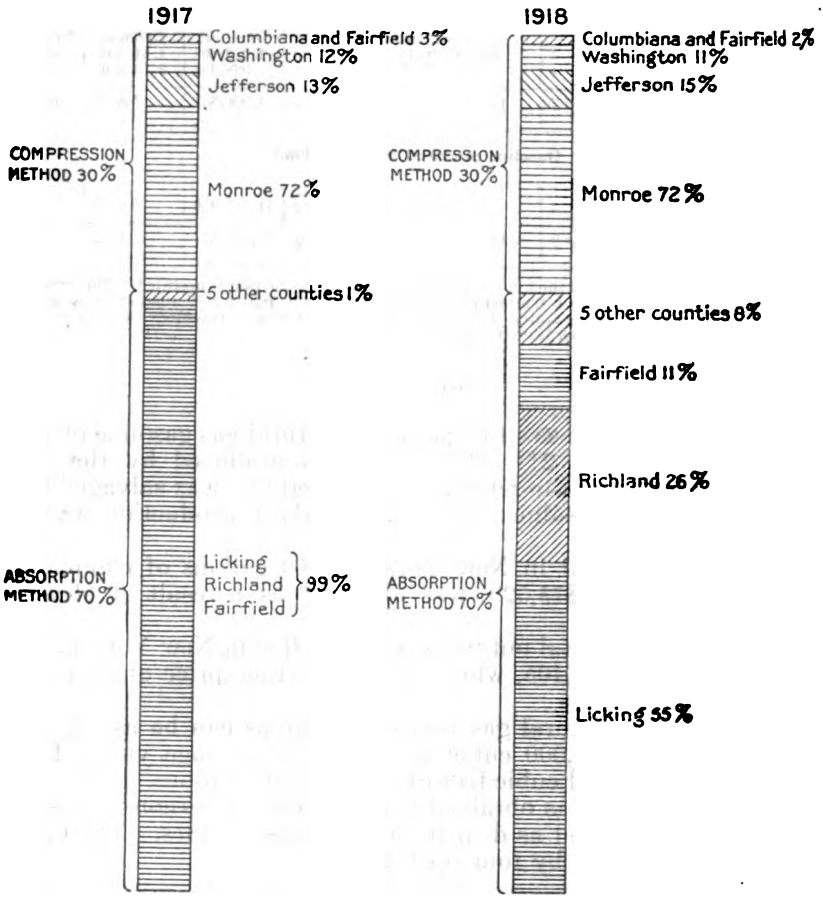

FIGURE 125.—Natural-gas gasoline produced in Ohio in 1917 and 1918, by principal methods of manufacture and by counties..

tion output and that derived from mains as drip was 20.4 cents a gallon, practically the same as in 1917.

The gasoline produced in 1918 was extracted from an estimated volume of 37,739,322,000 cubic feet of natural gas, with an average recovery of 0.18 gallon per thousand cubic feet. The average recovery of the compression gasoline was 2.87 gallons, and that of the absorption gasoline was 0.13 gallon.

During 1917 61 plants contributed to the gasoline production in Ohio, whereas in 1918, 55 were in operation—a decrease of about 10

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per cent. Of the 55 plants 45 were of the compression type and 10 were of the absorption type. The compression plants were in Columbiana, Fairfield, Jefferson, Monroe, and Washington counties; the absorption and drip gasoline came from Fairfield, Knox, Licking, Lorain, Monroe, Noble, Richland, and Washington counties.

The output in Ohio was produced by 36 operators, 28 of whom operated compression plants and 8 operated absorption plants and contributed drip gasoline.

The accompanying diagram (fig. 125) and the following tables show in detail the production of natural-gas gasoline in the State from 1916 to 1918.

Natural-gas gasoline produced in Ohio, 1916–1918.

1916.

County.	Number of operators.	Plants. Number.	Plants. Daily capacity.	Gasoline produced. Quantity.	Gasoline produced. Value.	Estimated volume of gas treated.	Range in yield of gasoline per thousand cubic feet of gas.	Range in gravity of gasoline as produced and before blending.
			Gallons.	*Gallons.*		*M cubic feet.*	*Gallons.*	*° Baumé.*
Monroe	14	28	4,562	1,446,917	$253,336	557,685	1.0–8.0	76–92
Jefferson	11	10	1,226	371,925	64,985	194,027	.5–3.7	82–100
Washington	8	10	858	239,866	41,789	70,575	1.0–5.0	82–91
Richland	1	[a] 1					.1046	78–86
Columbiana	2	2					[b] 3.5000	85–90
Fairfield	1	1	11,745	[c] 579,863	110,694	4,613,472	3.0000	85
Licking	1	[a] 1					.1084	77
Morgan	2	2					[b] 2.5000	[b] 89
	40	55	18,391	2,638,571	470,804	5,435,759	[b] .4850	76–100

1917.

Gasoline produced by compression and by vacuum pumps.

Monroe	14	29	5,235	1,689,541	$307,857	546,403	1.0 –6.0	76–92
Jefferson	11	10	1,312	293,554	53,672	122,060	1.5 –5.0	82–98
Washington	9	12	1,290	291,089	50,675	151,610	1.25–3.4	76–90
Columbiana	2	2	500	57,314	10,902	16,566	3.0 –3.5	85–89
Fairfield	1	1						
	37	54	8,337	2,331,498	423,106	836,639	[b] 2.70	76–98

Gasoline produced by absorption.

Licking	2	2	16,600	3,091,763	$625,004	29,062,512	0.10–0.229	78–86
Richland	2	2						
Fairfield	2	1						
Knox	1	1	200	16,299	3,266	162,990	.10– .25	69–75
Jefferson	1	1						
Noble [c]	1	.....						
Washington [c]	2	.....						
Monroe [c]	1	.....						
	12	7	16,800	3,108,062	628,270	29,225,502	[b] .106	69–86
Grand total	49	61	25,137	5,439,560	1,051,376	30,062,141	[b] .181	69–98

[a] Absorption plant. [b] Average. [c] Drip gasoline only.

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Natural-gas gasoline produced in Ohio, 1916–1918—Continued.

1918.

Gasoline produced by compression and by vacuum pumps.

County.	Number of operators.[a]	Number of plants.	Gasoline produced. Quantity.	Gasoline produced. Value.	Estimated volume of gas treated.	Range in yield of gasoline per thousand cubic feet of gas.	Range in gravity of gasoline as produced and before blending.
			Gallons.		*M cubic feet.*	*Gallons.*	° *Baumé.*
Monroe	14	28	1,481,112	$282,633	470,007	1.0 – 8.0	74–92
Jefferson	9	9	325,112	68,006	149,789	1.50–11.3	85–94
Washington	10	6	224,454	44,025	89,110	2.0 – 3.50	78–88
Columbiana	1	1	4,728	962	1,450	3.5	.....
Fairfield	1	1					
	[a] 28	45	2,035,406	395,626	710,356	[b] 2.87	74–94

Gasoline produced by absorption.[c]

Licking	2	2	2,574,737	$490,689	13,524,638	[b] 0.18	83–85
Richland	2	2	1,238,220	281,851	10,762,622	[b] 1.7	81–83
Fairfield	1	1				.4	66–80
Lorain	1	1				.....	.....
Washington	1	1	574,410	115,685	10,854,406	1.1	70–76
Noble	1	1				.33	82
Monroe	.....	.....				.....	.....
Knox	2	2	322,134	71,596	1,887,300	[b] .15	74–81
	[a] 8	10	4,709,501	959,821	37,028,966	[b] .13	66–85
Grand total	[a] 36	55	6,744,907	1,355,447	37,739,322	[b] .18	66–94

[a] This number is irrespective of the kind, number, and location of the plants operated. The sum of the number of operators listed for each method employed and for each county will therefore not give the correct number of operators in the State. A comparison with the number of operators for prior years can not be made because they have not been listed in the same way.

[b] Average.

[c] Includes drip gasoline.

OKLAHOMA.

The growth of the natural-gas gasoline industry in Oklahoma has been remarkable. From fourth in rank in 1911, Oklahoma advanced in 1914 to first place, which it has occupied for the last five years. The diagram (fig. 119) shows this rise in relation to the other States producing natural-gas gasoline.

In 1918 Oklahoma contributed 57.9 per cent of the total production in the United States, with an output of 163,700,550 gallons of raw gasoline. This quantity was an increase of 48,577,126 gallons, or 42.2 per cent, over the production in 1917. The quantity of raw gasoline received from the compression plants was 154,271,605 gallons, or 41.9 per cent greater than in 1917, and 94.2 per cent of the combined production for the State; the quantity recovered by absorption, including drip, was 9,428,945 gallons, 5.8 per cent of the total State production and 47.4 per cent more than the product by that method in 1917. Oklahoma contributed 70.2 per cent of the compression-plant gasoline produced in the United States in 1918, and 15 per cent of the total absorption-plant gasoline. The average daily production in 1918 was 448,495 gallons.

The quantity of commercial gasoline produced by blending the raw gasoline extracted from natural gas in Oklahoma in 1918 was 215,857,434 gallons, having an estimated value of $43,194,180. This production was greater than in any other State by a margin of 201,514,313 gallons over West Virginia, the nearest competitor.

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The market value of the entire output of raw gasoline in Oklahoma in 1918 was $28,389,045, a gain of 31.8 per cent over the value in 1917. The average price received at the source of production for all the gasoline in 1918 was 17.3 cents a gallon, which was a decrease of 1.41 cents as compared with the average price of 18.71 cents in 1917. The average selling price for the compression-plant product in Oklahoma in 1918 was 17.2 cents a gallon, a decrease of 1.5 cents as compared with 1917; the absorption product sold in 1918 for 19.8 cents a gallon, an increase of 0.72 cent over the price in 1917. The value of the raw compression gasoline in Oklahoma in 1918 was $26,521,398, and that of the absorption gasoline, including drip, was $1,867,647.

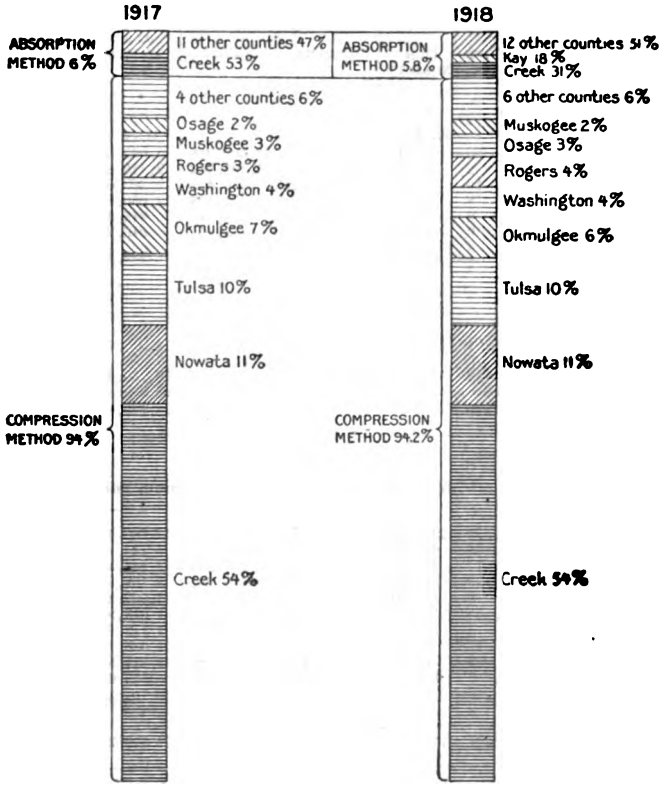

FIGURE 126.—Natural-gas gasoline produced in Oklahoma in 1917 and 1918, by principal methods of manufacture and by counties.

The gasoline produced was obtained from 78,322,307,000 cubic feet of natural gas, which was 6,397,634,000 cubic feet, or 7.6 per cent, less than the volume utilized in 1917. The compression plants used 46,684,983,000 cubic feet, and the absorption plants the remaining 31,637,324,000 cubic feet. The average yield of raw gasoline per thousand cubic feet for the entire output was 2.09 gallons; the compression product yielded 3.30 gallons and the absorption product 0.30 gallon, which was an increase over the yield in 1917 in both types.

The construction of new plants during 1918 resulted in the operation of 276 plants as compared with 234 in 1917, a gain of 42 plants, or 17.9 per cent. The compression plants numbered 238 in 1918, 31

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more than in 1917; the number of absorption plants in 1918 was 38, as compared with 27 in 1917.

Compression plants were run by 116 operators and absorption plants by 20 operators in 1918.

The accompanying diagram (fig. 126) and the following tables show in detail the production of natural-gas gasoline in Oklahoma from 1916 to 1918.

Natural-gas gasoline produced in Oklahoma, 1916–1918.

1916.

County.	Number of operators.	Plants. Number.	Plants. Daily capacity.	Gasoline produced. Quantity.	Gasoline produced. Value.	Estimated volume of gas treated.	Range in yield of gasoline per thousand cubic feet of gas.	Range in gravity of gasoline as produced and before blending.
			Gallons.	*Gallons.*		*M. cu. ft.*	*Gallons.*	*°Baumé.*
Creek	24	36	105,742	24,159,720	$2,500,218	6,032,636	1.4–7.8	72–96
Nowata	9	12	37,400	9,333,075	1,191,982	2,116,831	1.4–6.1	78–96
Tulsa	12	19	25,135	6,503,102	896,466	2,303,667	1.2–3.5	72–95
Okmulgee	13	18	20,100	3,082,438	431,409	2,080,671	.6–5.7	79–95
Washington	4	6	8,900	1,124,873	221,711	645,301	2.0–	82–89
Muskogee	8	9	6,000	1,086,536	158,211	616,791	1.3–3.5	64–90
Rogers	2	3	12,100	537,581	81,310	222,860	2.0–2.5	72–82
Pawnee	2	1					3.0	72
Kay	[a]2							
Osage	[a]1							
Total by compression		104	215,377	45,827,325	5,471,307	14,018,757	[b]3.269	64–96
Total by absorption and drip		12	17,700	2,532,277	393,838	10,730,697	[b].236	68–80
Grand total	77	116	233,077	48,359,602	5,865,145	24,749,454	[b]1.954	64–96

1917.

Gasoline produced by compression and by vacuum pumps.

Creek	38	72	244,747	57,365,695	$11,036,197	17,090,464	0.50–6.50	70–90
Tulsa	22	31	46,097	13,842,304	2,450,159	4,794,140	1.50–7.00	78–90
Nowata	14	17	48,190	12,379,140	2,300,282	3,544,339	1.06–7.45	74–90
Okmulgee	19	29	32,731	8,097,068	1,409,292	3,162,827	1.00–6.00	70–90
Rogers	5	10	15,256	4,805,265	783,811	1,902,294	1.75–3.98	75–85
Washington	12	15	19,275	3,761,253	757,135	1,918,941	.86–2.50	66–88
Osage	3	4	10,700	2,574,767	549,788	1,112,975	1.75–3.00	76–86
Muskogee	15	17	13,556	2,408,748	458,923	1,083,186	.85–3.98	68–87
Pawnee	5	5	7,880	1,809,746	232,249	1,217,560	1.30–2.52	72–85
Wagoner	3	3	12,100	1,508,236	307,873	513,634	1.58–3.50	80–90
Carter	1	2	1,100	175,991	35,358	58,920		[b]78.8
Kay	1	2	5,000				[b]3.00	[b]80
	138	207	456,632	108,728,213	20,321,067	36,399,280	[b]2.987	66–90

Gasoline produced by absorption.

Creek	9	12	12,881	3,180,724	$584,897	20,088,076	0.086–1.500	45–76
Kay	3	4	9,720	915,613	181,801	4,666,230	.172–.190	62–76
Osage	2	3	3,501	397,850	82,496	6,335,195	.058–1.160	50–74
Pawnee	1	2	5,852				[b].370	
Payne	1	1					.150	74
Lincoln	1	1	2,650				.045	74–76
Okmulgee	2	1					.10	70
Rogers [c]	1			1,901,024	371,654	17,231,160		70
Nowata [c]	3							63–72
Tulsa	3	1	1,200				2.00	54–76
Oklahoma	1	1						68
Muskogee	1	1					.50	60
Washington [c]	1							65
	29	27	35,804	6,395,211	1,220,838	48,320,661	[b].1323	45–76
Grand total	167	234	492,436	115,123,424	21,541,905	84,719,941	[b]1.359	45–90

[a] Absorption plants and drip gasoline only. [b] Average. [c] Drip gasoline only.

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Natural-gas gasoline produced in Oklahoma, 1916–1918—Continued.

1918.

Gasoline produced by compression and by vacuum pumps.

County.	Number of operators.[a]	Number of plants.	Gasoline produced. Quantity.	Gasoline produced. Value.	Estimated volume of gas treated.	Range in yield of gasoline per thousand cubic feet of gas.	Range in gravity of gasoline as produced and before blending.
			Gallons.		*M cu. ft.*	*Gallons.*	°*Baumé.*
Creek	42	78	83,853,919	$14,254,783	23,787,025	1.0 –7.59	70–90
Nowata	17	23	16,337,260	2,105,928	4,209,713	1.25–9.5	70–90
Tulsa	26	36	16,027,265	3,121,213	4,735,041	1.6 –4.2	69–86
Okmulgee	17	26	9,322,162	1,646,597	2,744,299	.80–6.2	70–90
Washington	12	19	6,453,647	1,307,701	2,407,287	1.0 –4.0	69–88
Rogers	6	9	5,289,743	889,049	1,118,587	2.5 –6.0	79–87
Osage	5	6	5,143,912	973,662	3,364,696	1.0 –2.74	72–88
Wagoner	4	5	3,109,666	698,856	776,844	2.7 –5.7	73–90
Pawnee	6	6	2,904,671	441,332	1,055,127	1.2 –5.18	72–85
Muskogee	14	17	2,901,520	580,170	1,071,540	.85–4.1	72–86
Carter	4	7	1,001,715	122,537	762,962	1.0 –5.0	80–89
Garfield	2	2	613,465	163,366	234,418	2.25–3.5	76–96
Kay	1	2	1,312,660	216,204	417,444	[b] 5.0	[b] 85
Payne	2	2				.8 –1.04	74–80
	[a] 116	238	154,271,605	26,521,398	46,684,983	[b] 3.30	69–96

Gasoline produced by absorption.[c]

Creek	7	11	2,906,992	$489,436	3,893,202	1.0 –2.50	60–84
Kay	2	4	1,725,703	386,379	6,306,836	.125–1.20	75
Osage	6	8	1,605,882	346,262	15,578,123	.10 –2.40	52–79
Pawnee	3	4	1,237,479	256,597	830,352	.125–1.00	74–80
Payne	1	2				[b] .15	[b] 74
Lincoln	1	1				.125	74–76
Oklahoma	1	1				.25	.....
Wagoner	1	1	955,888	199,916	4,840,123	2.00	78
Rogers[d]	.....	.....				.....	.....
Nowata[d]	.....	.....				.....	60–90
Washington[d]	.....	.....				.....	.....
Okmulgee	2	2	521,240	125,786	2,000	.2 –1.0	64–72
Carter	2	2	388,045	43,859	119,780	2.3 –3.5	80
Tulsa	2	2	87,716	19,412	66,908	[b] .125	74–76
	[a] 20	38	9,428,945	1,867,647	31,637,324	[b] .30	52–90
Grand total	[a] 133	276	163,700,550	28,389,045	78,322,307	[b] 2.09	52–96

[a] This number is irrespective of the kind, number, and location of the plants operated. The sum of the number of operators listed for each method employed and for each county will therefore not give the correct number of operators in the State. A comparison with the number of operators for prior years can not be made because they have not been listed in the same way.
[b] Average.
[c] Includes drip gasoline.
[d] Drip gasoline only.

PENNSYLVANIA.

For the fifth consecutive year Pennsylvania in 1918 held fourth rank among the States producing natural-gas gasoline. Its production of 15,775,058 gallons constituted 5.6 per cent of the total output of the country and was an increase of 14 per cent over 1917. It consisted of 9,158,795 gallons of raw gasoline recovered by the compression and vacuum-pump methods and 6,616,263 gallons supplied by absorption plants, including drip gasoline from the mains. This was a gain over the production in 1917 of 1.6 per cent in compression gasoline and of 37.4 per cent in absorption and drip gasoline. The production by the compression and vacuum-pump method was 58.1 per cent of the State production in 1918 and 4.2 per cent of the total production in the United States by these methods. The absorption

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plants, including drip, produced 41.9 per cent of the State's output in 1918 and 10.5 per cent of the total absorption and drip gasoline recovered in the United States in 1918. The actual increase in the combined production in 1918 was 1,948,808 gallons, which resulted from an increased output of 147,596 gallons by the compression plants and 1,801,212 gallons by the absorption plants. The average daily production in the State in 1918 was 43,219 gallons.

The output of commercial gasoline in the State in 1918 was 9,873,707 gallons, obtained by blending the raw product with naphthas and various distillates. It has been estimated that this quantity had a value of $1,998,418.

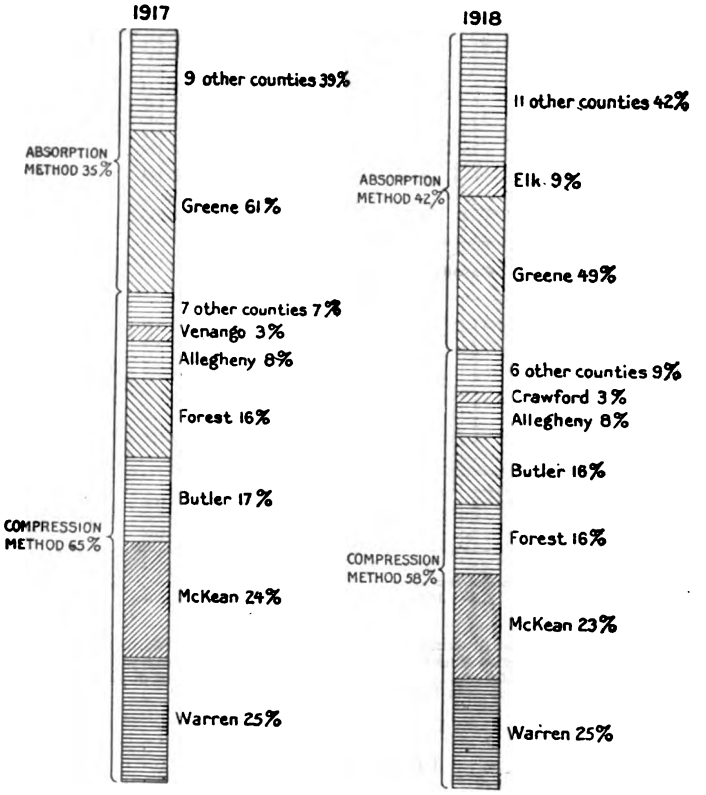

FIGURE 127.—Natural-gas gasoline produced in Pennsylvania in 1917 and 1918, by principal methods of manufacture and by counties.

The combined output was valued at $3,249,233 in 1918, a gain of $471,135, or 17 per cent, over 1917, and consisted of compression gasoline valued at $1,793,334 and absorption gasoline valued at $1,455,899. The values of gasoline produced by both processes increased over those in 1917. The raw gasoline obtained at the compression plants brought an average price in 1918 of 19.6 cents a gallon, which was slightly less than in 1917, whereas the absorption and drip gasoline increased in average price from 20.47 cents a gallon in 1917 to 22 cents a gallon in 1918, a gain of 7.5 per cent. The average selling price for the combined output in 1918 was 20.6 cents a gallon, or 2.9 per cent gain over the average price in 1917.

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The gasoline was extracted from approximately 56,982,063,000 cubic feet of natural gas, making an average yield of 0.28 gallon of raw gasoline per thousand cubic feet of gas used, practically the same as in 1917. The average yield per thousand cubic feet at the compression plants was 2.33 gallons in 1918, a loss of 0.19 gallon, or 7.5 per cent, and at the absorption plants the yield was 0.12 gallon.

Pennsylvania outranks all other States in the total number of gasoline-extraction plants. In 1918 there were in operation 282 plants, an increase of 31 plants, or 12.35 per cent, over the number in operation in 1917. The compression plants numbered 259 in 1918, as compared with 234 in 1917, a gain of 10.7 per cent, and the absorption plants increased from 17 to 23, a gain of 35.3 per cent. The plants in operation in 1918 were distributed over 14 counties in the State, of which 12 contained compression plants and 13 absorption plants.

The combined output in 1918 was produced by 200 operators, of whom 192 conducted compression plants and 12 conducted absorption plants.

The accompanying diagram (fig. 127) and the following tables show in detail the natural-gas gasoline industry in Pennsylvania from 1916 to 1918.

Natural-gas gasoline produced in Pennsylvania, 1916–1918.

1916.

County.	Number of operators.	Plants. Number.	Plants. Daily capacity.	Gasoline produced. Quantity.	Gasoline produced. Value.	Estimated volume of gas treated.	Range in yield of gasoline per thousand cubic feet of gas.	Range in gravity of gasoline as produced and before blending.
			Gallons.	*Gallons.*		*M cubic ft.*	*Gallons.*	*°Baumé.*
McKean	11	12	9,085	1,780,159	$315,799	733,417	1.5–3.0	71–92
Warren	32	40	5,245	1,513,725	286,860	437,259	1.0–8.0	66–98
Butler	79	87	5,175	1,277,516	219,387	485,598	.5–6.0	64–90
Forest	10	11	4,066	878,625	163,750	324,344	2.0–5.0	85–94
Allegheny	7	15	2,700	693,109	124,859	175,950	1.5–5.0	78–87
Venango	6	5	2,250	324,750	60,552	386,330	.5–5.0	85–90
Washington	4	4	255	87,671	16,250	39,355	1.0–5.0	80–86
Beaver	3	3	120	26,700	4,986	9,200	2.5–5.0	80–86
Potter	[a] 15	1	1,391	140,115	24,274	101,762	1.0	90
Clarion		2					1.0–2.0	77–80
Crawford		1					1.0–5.0	85
Armstrong		2					.5–4.5	76–85
Greene		2					[b] 2.5	.....
Total by compression and vacuum	.....	185	30,287	6,722,370	1,216,717	2,693,215	[b] 2.496	64–98
Total by absorption and drip	.....	10	16,200	2,992,556	509,456	35,797,406	[b] .084	70–83
Grand total	167	195	46,487	9,714,926	1,726,173	38,490,621	[b] .252	64–98

[a] Includes one company operating an absorption plant in Elk County.
[b] Average.

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Natural-gas gasoline produced in Pennsylvania, 1916–1918—Continued.

1917.

Gasoline produced by compression and by vacuum pumps.

County.	Number of operators.	Plants. Number.	Plants. Daily capacity.	Gasoline produced. Quantity.	Gasoline produced. Value.	Estimated volume of gas treated.	Range in yield of gasoline per thousand cubic feet of gas.	Range in gravity of gasoline as produced and before blending.
			Gallons.	*Gallons.*		*M cu. ft.*	*Gallons.*	°*Baumé.*
Warren	40	33	6,287	2,292,878	$453,012	765,503	0.75–7.00	66–100
McKean	13	14	8,804	2,186,192	502,284	997,282	.75–3.00	85–90
Butler	103	115	5,461	1,490,324	262,713	524,727	1.00–6.00	70–90
Forest	20	21	5,113	1,398,486	259,210	462,646	2.00–5.00	72–92
Allegheny	8	16	2,660	764,129	149,248	207,143	1.25–5.00	78–98
Venango	5	5	1,520	276,660	51,754	363,191	2.50–3.95	82–90
Beaver	8	8	830	209,465	41,635	73,725	2.00–5.00	78–95
Crawford	3	3	422	135,447	25,011	49,071	2.00–5.00	82–90
Clarion	8	7	627	103,747	18,924	65,806	1.00–4.00	75–92
Washington	3	6	370	101,734	18,575	34,940	1.00–5.00	76–84
Armstrong	3	4	120	38,950	7,367	15,847	1.00–5.00	72–85
Potter	1	1	350	13,187	2,697	12,475	1.00–2.50	76–95
Greene	1	1						
	216	234	32,564	9,011,199	1,792,430	3,572,356	[a] 2.522	66–100

Gasoline produced by absorption.[b]

Greene	3	3	12,150	2,936,893	$580,240	25,497,909	0.1031–0.1200	78–80
Warren	2	1	5,300				.1195	71–82
Venango	4	1					.123	65–80
Clarion	3	3	970				.052–.143	69–80
Potter	2	2	1,400				.24–.30	78–87
Elk	2	1					.0826	69–80
Armstrong	2	2	1,550	1,878,158	405,428	20,416,791	[a] .067	69–73
Allegheny	2	1					.077	70–80
Washington	4	2					.1522–.172	55–80
Butler	43	.....	5,230				.....	52–88
Forest	2	1					.....	71–80
McKean	1	.....	.....				.....	69
Jefferson	1	.....	.....				.....	69
	71	17	26,600	4,815,051	985,668	45,914,700	[a] .105	52–88
Grand total	287	251	59,164	13,826,250	2,778,098	49,487,056	[a] .279	52–100

[a] Average.

[b] Includes drip gasoline.

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Natural-gas gasoline produced in Pennsylvania, 1916–1918—Continued.

1918.

Gasoline produced by compression and by vacuum pumps.

County.	Number of operators.[a]	Number of plants.	Gasoline produced. Quantity.	Gasoline produced. Value.	Estimated volume of gas treated.	Range in yield of gasoline per thousand cubic feet of gas.	Range in gravity of gasoline as produced and before blending.
			Gallons.		*M cu. ft.*	*Gallons.*	°*Baumé.*
Warren	35	55	2,207,814	$484,993	843,796	1.50–3.5	71–92
McKean	13	15	2,107,222	471,707	1,033,754	.5 –3.5	80–92
Forest	17	21	1,480,527	228,485	522,202	2.0 –5.0	75–90
Butler	91	110	1,449,876	261,237	632,656	1.0 –7.0	68–90
Allegheny	10	19	723,117	135,950	189,706	.25–5.0	72–90
Crawford	4	4	257,701	43,087	89,425	2.0 –5.0	85–91
Venango	7	7	238,104	44,729	283,039	.45–3.0	80–90
Beaver	8	9	213,020	44,992	81,037	2.25–5	78–90
Armstrong	3	4	161,519	32,304	64,154	1.0 –5.0	72–84
Clarion	9	9	126,195	23,420	126,954	1.0 –3.0	75–88
Washington	3	5	130,640	22,430	64,400	1.00–5.0	76–84
Potter	1	1				1.0	95
	[a] 192	259	9,158,795	1,793,334	3,937,123	[b] 2.33	68–95

Gasoline produced by absorption.[c]

Greene	3	5	3,221,861	$733,310	25,416,561	0.10–1.0	70–80
Venango	1	2				[b] .174	74–87
McKean	1	1				.086	87
Warren	1	1				.118	84
Washington	1	1	2,023,624	421,877	17,452,899	.172	55–78
Armstrong	1	2				[b] .086	[b]78
Allegheny	1	1				.03	62–80
Beaver	1	1				.10	
Butler[d]							60–87
Elk	2	2	605,538	134,939	5,377,612	.10 – .11	80–84
Forest	2	2	261,073	56,765	292,970	[b] .19	[b]80
Clarion	2	2	255,275	55,542	3,869,522	.056– .098	72–83
Potter	3	3	245,892	53,466	635,376	.257–1.0	80–82
	[a] 12	23	6,616,263	1,455,899	53,044,910	[b] .12	55–87
Grand total	[a] 200	282	15,775,058	3,249,233	56,982,063	[b] .28	55–95

[a] This number is irrespective of the kind, number, and location of the plants operated. The sum of the number of operators listed for each method employed and for each county will therefore not give the correct number of operators in the State. A comparison with the number of operators for prior years can not be made because they have not been listed in the same way.
[b] Average.
[c] Includes drip gasoline.
[d] Drip gasoline only.

TEXAS.

Texas retained fifth rank among the States producing natural-gas gasoline in 1918, the output credited to the State being 7,326,122 gallons, which was 405,717 gallons, or 5.9 per cent, more than in 1917. This quantity constituted 2.6 per cent of the total output of natural-gas gasoline in the United States in 1918. The compression plants contributed 4,024,898 gallons of gasoline, which was 54.9 per cent of the combined output in the State, and the absorption plants, including drip, supplied 3,301,224 gallons, or 45.1 per cent. The compression gasoline was 1.8 per cent of the total compression and vacuum-pump production in the United States in 1918, and the

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absorption gasoline, including drip, constituted 5.3 per cent of the total quantity of gasoline recovered by this method in the country in 1918. The average daily production of all plants in 1918 was 20,072 gallons.

The quantity of commercial gasoline produced by the blending of the raw gasoline with various distillates, at the plants or by the refiners, was estimated at about 5,912,665 gallons, valued at approximately $979,162.

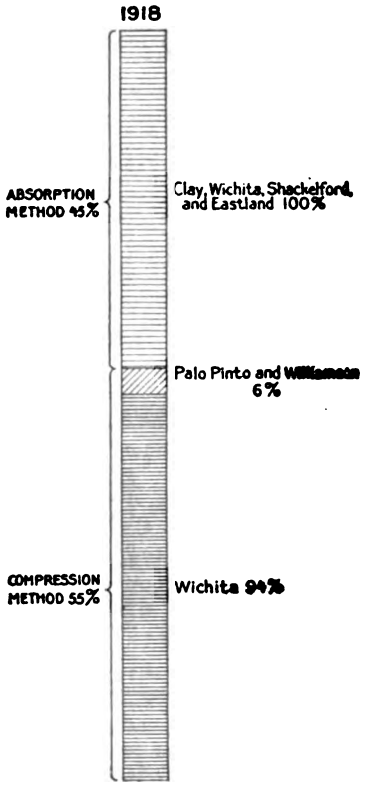

FIGURE 128.—Natural-gas gasoline produced in Texas in 1918, by principal methods of manufacture and by counties.

The market value of the total output of raw gasoline in 1918 was $1,214,565, an increase of 5.7 per cent over 1917. The compression-plant and vacuum-pump product was valued at $618,941, and the product of the absorption process, including drip gasoline, was valued at $595,624.

The average price received for the combined output of raw gasoline from both processes at the plants in 1918 was 16.6 cents a gallon, the same as that received in 1917.

The quantity of natural gas from which gasoline was recovered in 1918 was estimated at 8,493,182,000 cubic feet, 1,575,010,000 cubic feet being utilized by the compression method and 6,918,172,000 cubic feet by the absorption process. The average recovery of raw gasoline per thousand cubic feet by all methods was 0.86 gallon, or an increase of 0.31 gallon over 1917. The natural gas utilized in the manufacture of the raw gasoline was either produced by the operators themselves or purchased from other producers. The gas, after the extraction of the gasoline, was used for fuel directly on the leases or returned to the pipe lines for distribution.

The number of plants, of all types, recovering gasoline from natural gas, increased from 11 in 1917 to 13 in 1918. Returns on the production of gasoline were received from 9 compression plants and four absorption plants. The operators responsible for the output in 1918 numbered 8.

The accompanying diagram (fig. 128) and the following tables show the quantity of natural-gas gasoline produced in Texas from 1916 to 1918.

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Natural-gas gasoline produced in Texas, 1916–1918.

1917.

County.	Number of operators.	Plants. Number.	Plants. Daily capacity.	Gasoline produced. Quantity.	Gasoline produced. Value.	Gas used. Estimated volume.	Gas used. Range in yield of gasoline per thousand cubic feet.	Range in gravity of gasoline as produced and before blending.
			Gallons.	*Gallons.*		*M cubic feet.*	*Gallons.*	°*Baumé.*
Wichita	5	6	9,900	3,785,767	$633,516	2,517,346	1.0–6.5	79.9–90.0
Clay	2	2						
Williamson	1	1	22,650	3,134,638	515,925	10,159,870	.1–4.0	76 –83
Shackelford	1	1						
Palo Pinto	1	1						
	10	11	[a] 32,550	6,920,405	1,149,441	12,677,216	[b] .546	76 –90
Total, 1916	3	4	6,688	1,292,811	201,023	948,485	[b] 1.363	87 –92

[a] Includes 1 operator in Clay County and 1 in Shackelford County that use absorption method.
[b] Average.

1918.

Gasoline produced by compression and by vacuum pumps.

County.	Number of operators.[a]	Number of plants.	Gasoline produced. Quantity.	Gasoline produced. Value.	Estimated volume of gas treated.	Range in yield of gasoline per thousand cubic feet of gas.	Range in gravity of gasoline as produced and before blending.
			Gallons.		*M cubic feet.*	*Gallons.*	°*Baumé.*
Wichita	6	7	3,797,215	$574,622	1,486,680	2.05–6.1	70–80
Palo Pinto	1	1	227,683	44,319	88,330	3.5	70
Williamson	1	1				2.0	75
	[a] 6	9	4,024,898	618,941	1,575,010	[b] 2.56	70–80

Gasoline produced by absorption.[c]

Clay	1	1				0.48	84
Wichita	1	1	3,301,224	$595,624	6,918,172	.32	81
Shackelford	1	1				.16	76
Eastland	1	1				.25	80
	4	4	3,301,224	595,624	6,918,172	[b] .48	76–84
Grand total	[a] 8	13	7,326,122	1,214,565	8,493,182	[b] .86	70–84

[a] This number is irrespective of the kind, number, and location of the plants operated. The sum of the number of operators listed for each method employed and for each county will therefore not give the correct number of operators in the State. A comparison with the number of operators for prior years can not be made because they have not been listed in the same way.
[b] Average.
[c] Includes drip gasoline.

WEST VIRGINIA.

West Virginia in 1918 remained second in rank for the third consecutive year among the States engaged in the natural-gas gasoline industry. Its production of 37,603,903 gallons was the State's largest output since the inception of the industry and was 13.3 per cent of the total production in the United States in 1918. This quantity surpassed the output in 1917 by 4,935,256 gallons, an increase of 15.1 per cent.

West Virginia ranked third among the States in the quantity of raw gasoline produced by the compression plants and vacuum pumps,

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with 5.3 per cent of the total compression product in the United States. In the absorption-plant product, which in 1918 was 41.4 per cent of the total absorption gasoline produced in the United States, West Virginia leads all other States, exceeding Oklahoma; its nearest competitor, by 26.4 per cent. The total output at the compression plants in 1918 was 11,612,114 gallons, a decrease of 664,670 gallons, or 5.4 per cent, as compared with the output in 1917. The production at the absorption plants was 25,991,789 gallons, a gain of

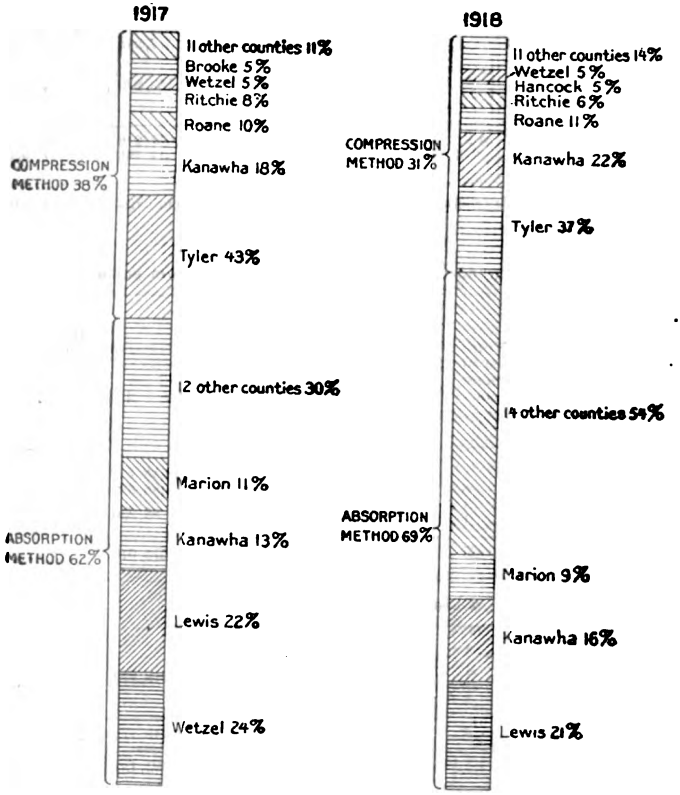

FIGURE 129.—Natural-gas gasoline produced in West Virginia in 1917 and 1918, by principal methods of manufacture and by counties.

5,599,926 gallons, or 27.5 per cent. This marked increase accounts for the State's record output in 1918. Absorption plants contributed 69.1 per cent and compression plants 30.9 per cent of the combined output in the State.

Approximately 14,343,121 gallons of commercial gasoline, valued at $2,858,279, was produced in the process of blending the raw gasoline. This was the second largest quantity of commercial gasoline produced in the United States in 1918.

The market value of the total output of raw gasoline amounted to $7,498,804, an increase of $986,991, or 15.2 per cent; of this combined value absorption gasoline contributed $5,307,437 and compression gasoline $2,191,367. The average price received during 1918 for

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the State's product was 19.9 cents a gallon, practically the same as in 1917. The compression gasoline averaged 18.9 cents a gallon and the absorption gasoline 20.4 cents a gallon, a gain of 0.86 cent, or 4.8 per cent, over the average unit selling price for the compression gasoline in 1917 and a loss of 0.67 cent, or 3.2 per cent a gallon, as compared with the average price received for absorption gasoline in 1917.

The gasoline produced was extracted from approximately 163,929,550,000 cubic feet of natural gas, which, despite an increased production, was less, by 3,841,801,000 cubic feet, or 2.3 per cent, than the volume utilized in 1917. Of this volume, 96.8 per cent was used at the absorption plants and 3.2 per cent at the compression plants.

At the end of 1918 there were 208 gasoline plants in operation in West Virginia, of which 172 were compression plants and 36 absorption plants. Compared with 188 plants in 1917, including 159 compression plants and 29 absorption plants, this shows an increase of 10.6 per cent in the total number of plants, or a gain of 8.2 per cent in compression plants and of 24.1 per cent in absorption plants. The gasoline plants are located in 22 counties.

The activities of 79 operators were responsible for the record output in 1918.

The accompanying diagram (fig. 129) and the following tables show in detail the natural-gas gasoline industry in West Virginia from 1916 to 1918.

Natural-gas gasoline produced in West Virginia, 1916–1918.

1916.

County.	Number of operators.	Plants. Number.	Plants. Daily capacity.	Gasoline produced. Quantity.	Gasoline produced. Value.	Estimated volume of gas treated.	Range in yield of gasoline per thousand cubic feet of gas.	Range in gravity of gasoline as produced and before blending.
			Gallons.	*Gallons.*		*M cubic ft.*	*Gallons.*	°*Baumé.*
Tyler	19	53	14,430	4,424,890	$780,928	1,501,201	0.8– 6.0	75–92
Kanawha	8	7	9,287	1,566,461	287,856	469,887	2.5– 5.0	76–90
Ritchie	11	15	3,628	1,011,902	175,566	568,667	.8– 3.3	80–90
Brooke	11	11	2,689	626,464	111,893	193,029	2.0– 3.5	80–94
Wetzel	9	8	1,832	420,369	76,579	254,065	1.0– 2.0	70–85
Hancock	8	6	1,260	314,458	52,685	79,303	2.0–10.0	78–90
Pleasants	15	19	1,690	299,025	46,852	121,348	2.0– 3.0	72–90
Roane	3	3	970	261,940	44,850	124,891	1.3– 3.0	80–88
Wood	6	4	680	59,472	8,510	26,274	1.2– 3.0	80–86
Harrison		2					.5– 1.5	84–85
Doddridge		2					1.0– 2.5	81–88
Clay	a15	1	2,810	304,643	56,312	211,858	2.0	82
Wirt		1					3.0	89
Calhoun		1					.5	92
Total by compression and vacuum		133	39,276	9,289,624	1,642,031	3,550,523	b2.616	70–95
Total by absorption and drip		14	59,383	9,475,432	1,383,262	101,114,013	b.094	68–86
Grand total	105	147	98,659	18,765,056	3,025,293	104,664,536	b.179	68–95

a Includes operators having absorption plants in Monongalia, Cabell, Jackson, Lewis, and Marion counties.
b Average.

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Natural-gas gasoline produced in West Virginia, 1916–1918—Continued.

1917.

Gasoline produced by compression and by vacuum pumps.

County.	Number of operators.	Plants. Number.	Plants. Daily capacity.	Gasoline produced. Quantity.	Gasoline produced. Value.	Estimated volume of gas treated.	Range in yield of gasoline per thousand cubic feet of gas.	Range in gravity of gasoline as produced and before blending.
			Gallons.	*Gallons.*		*M cu. ft.*	*Gallons.*	°*Baumé.*
Tyler	22	60	15,226	5,294,771	$935,133	1,517,753	0.75–6.00	75 –96
Kanawha	6	11	10,108	2,211,717	427,172	811,770	.50–3.75	72 –92
Roane	6	7	3,481	1,254,068	209,250	750,340	1.40–2.00	77.5–88
Ritchie	15	19	3,860	1,000,308	185,331	487,576	.25–3.30	76 –90
Wetsel	8	10	2,310	557,209	101,795	317,631	1.00–2.10	76 –88
Brooke	10	12	3,865	538,073	101,764	232,636	2.00–6.00	74 –92
Pleasants	13	19	1,372	410,531	67,080	215,029	1.50–3.00	70 –89
Hancock	7	6	1,211	382,247	69,602	102,670	1.50–6.00	78 –90
Wood	5	5	307	60,948	10,500	33,609	1.50–2.50	80 –88
Harrison	1	1	1,600				1.50	81
Clay	2	2					.94–2.00	73 –80
Doddridge	2	2	477				1.00–2.50	82 –88
Lewis	1	1	359	506,817	103,767	406,634	1.80	83
Calhoun	2	2					.75–1.00	78 –90
Marshall	1	.....	.....				.....	80
Wirt	1	1	173				2.50	89
Marion	1	1					2.00	85
	103	159	44,348	12,276,784	2,211,494	4,845,648	[a] 2.53	70 –96

Gasoline produced by absorption.[b]

Wetsel	3	4	20,100	4,884,011	$1,065,021	46,555,910	0.1050	68–79
Lewis	2	4	23,000	4,428,527	962,063	31,261,900	0.1364–.1452	[a]78
Kanawha	3	5	12,837	2,706,456	539,893	24,788,263	.0300–.1900	83–88.5
Marion	4	4	8,800	2,241,142	479,112	16,521,800	.1285–.1660	68–80
Cabell	1	1					.1600	83
Jackson	1	1					.1900	82
Wood	1	1					.0794	80
Harrison	1	1					.0964	80
Lincoln	1	1					.1000	85
Tyler	1	1					.2057	82
Clay	1	1	26,578	6,131,727	1,264,230	43,797,830	.0500	.....
Ritchie	1	1					.0460	78
Monongalia	1	1					.2340	76
Putnam	1	1					.0800	88
Doddridge	1	2					[a] 1.250	.....
Hancock[c]	2	.....					.....	75
	25	29	91,315	20,391,863	4,300,319	162,925,703	[a] 1.250	68–88.5
Grand total	128	188	135,663	32,668,647	6,511,813	167,771,351	[a] .195	68–96

[a] Average. [b] Includes drip gasoline. [c] Drip gasoline only.

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Natural-gas gasoline produced in West Virginia, 1916–1918—Continued.

1918.

Gasoline produced by compression and by vacuum pumps.

County.	Number of operators.[a]	Number of plants.	Gasoline produced. Quantity.	Gasoline produced. Value.	Estimated volume of gas treated.	Range in yield of gasoline per thousand cubic feet of gas.	Range in gravity of gasoline as produced and before blending.
			Gallons.		*M cubic feet.*	*Gallons.*	°*Baumé.*
Tyler	23	62	4,255,558	$829,446	1,452,694	2.0–4.0	75–87
Kanawha	6	12	2,503,369	467,493	1,321,502	.99–4.0	80–94
Roane	6	8	1,296,262	220,730	515,611	1.4 –4.0	72–90
Ritchie	14	18	700,739	135,583	499,379	.50–3.0	74–90
Hancock	6	11	581,132	105,999	154,684	1.5 –6.0	88–91
Wetzel	7	10	566,871	115,999	359,773	.33–3.0	75–86
Brooke	10	14	511,007	97,621	214,001	1.5 –3.5	74–94
Pleasants	9	18	379,381	65,012	201,456	1.5 –4.0	75–88
Clay	2	2	278,236	55,647	243,500	.96–1.25	80–82
Doddridge	2	3	235,906	42,304	114,646	2.00–2.5	83–88
Harrison	1	1	232,129	42,808	101,050	3.00	83
Marion	1	1				2.00	80
Lewis	1	1				0.18	83
Calhoun	1	2				[b] 1.6	80–90
Marshall	1	2				[b] 2.50	[a] 80
Wood	5	5	67,229	11,807	40,099	.50–2.50	80–86
Wirt	2	2	2,295	918	345	[b] .66	[a] 82
	[a] 71	172	11,612,114	2,191,367	5,218,740	[b] 2.23	72–94

Gasoline produced by absorption.[c]

Lewis	3	5	5,545,531	$1,069,607	31,909,291	0.16–0.17	73–85
Wetzel	1	3	10,935,875	2,337,195	81,186,817	.11–2.00	68–80
Cabell	1	1				.20	88
Jackson	1	1				.18	88
Lincoln	1	1				.14	88
Wood	1	1				.07	78–83
Doddridge	1	1				.20	82
Putnam	1	1				.125	84–92
Pleasants						.15	80–87
Hancock	1	1				.10	80
Braxton	1	1				.25	79
Kanawha	4	6	4,205,567	837,917	22,994,462	.10– .33	80–82
Marion	3	4	2,346,881	437,398	12,494,089	.11– .18	78–81
Harrison	2	3	1,729,589	370,124	2,221,402	.16– .20	80–86
Tyler	2	3	989,084	204,970	6,572,728	.18– .50	[a] 86
Ritchie	2	2	136,250	28,923	546,305	.13– .75	79–90
Clay	2	2	103,012	21,303	785,716	.10– .25	[a] 80
	[a] 12	36	25,991,789	5,307,437	158,710,810	[b] .16	68–92
Grand total	[a] 79	208	37,603,903	7,498,804	163,929,550	[b] .23	68–94

[a] This number is irrespective of the kind, number, and location of the plants operated. The sum of the number of operators listed for each method employed and for each county will therefore not give the correct number of operators in the State. A comparison with the number of operators for prior years can not be made because they have not been listed in the same way.

[b] Average.

[c] Includes drip gasoline.

WYOMING.

The construction of gasoline plants in Wyoming in 1917 resulted in the production of 1,579,526 gallons of raw gasoline in 1918, the first production made by that State. The value of the output was estimated at $268,339. The average price at the plants during 1918 was 17 cents a gallon.

It is estimated that 2,519,052 gallons of commercial gasoline, valued at $407,406, was produced in Wyoming in 1918.

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COKE.

By C. E. Lesher and F. G. Tryon.[1]

INTRODUCTION.

The statistical work on coke conducted by the Geological Survey during the year 1918 was merged in the larger undertaking of the statistical division of the United States Fuel Administration. For the special statistics on coke collected during the war period the reader is referred to the report of the distribution division of the United States Fuel Administration, Part I of which, "The distribution of coal and coke," is a running account of the problems that faced the Fuel Administration in meeting the country's expanded requirements and of the measures taken to meet those problems. In Part III of the same report, "Statistical tables," will be found certain other data on coke. A list of references to tables and text concerning coke which are to be found in these reports is appended to this chapter. The present report will be practically confined to setting forth the results of the 1918 canvass of coke production conducted in customary fashion by the Geological Survey. The tables are given in a form to preserve the continuity of the records collected by the Survey since 1880. The report herewith thus consists of a skeleton only; for the flesh and blood of the story of how the coke industry was drafted into war service the reader is referred to the reports of the Fuel Administration mentioned above.

ACKNOWLEDGMENTS.

Without the hearty support of the producers of coke, thanks for which are cordially extended, the preparation of this report would have been impossible. To the railroads which supplied weekly or even daily information of cars of coke loaded acknowledgments are also due. The statistics were collected and compiled under the direction of the senior author; the text has been prepared by the junior author. Portions of the proof have been read by Mr. Howard N. Eavenson, for whose helpful suggestions many thanks are due.

UNIT OF MEASUREMENT.

The standard unit of measurement employed in the coke industry in the United States is the short or net ton of 2,000 pounds. Except where otherwise specified, this is the unit employed throughout this chapter.

REVIEW OF THE COKE INDUSTRY IN 1918.

For the coke industry, as for the mining of coal, the year 1918 was one of maximum production, the climax of the extraordinary

[1] The statistics in this report were collected and prepared by H. L. Bennit, of the United States Geological Survey, except those for imports and exports, which were compiled by J. A. Dorsey from records of the Bureau of Foreign and Domestic Commerce.

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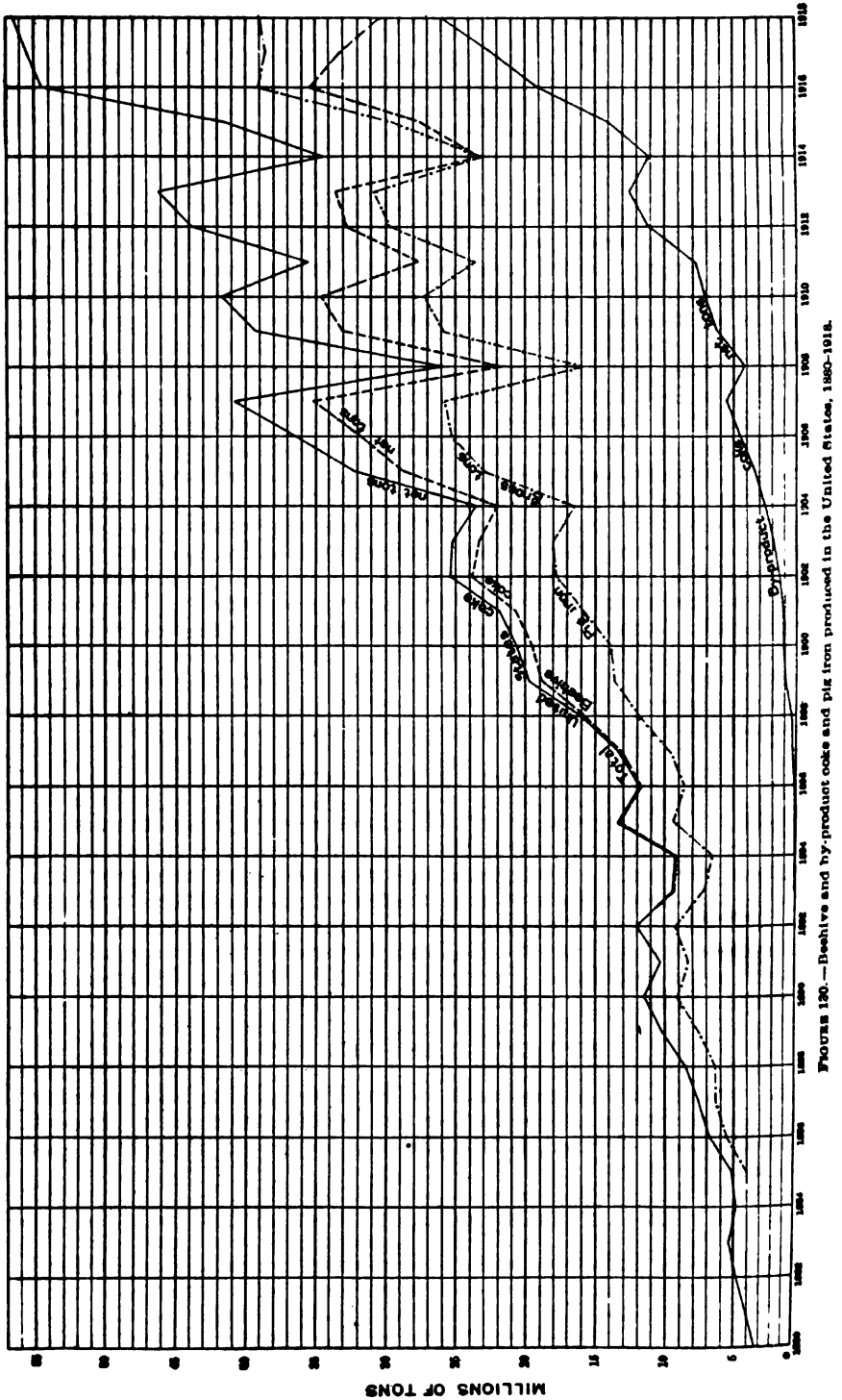

FIGURE 130.—Beehive and by-product coke and pig iron produced in the United States, 1880–1918.

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industrial activity which marked in the United States the period of the World War. The record was the more remarkable in that it was achieved in spite of transportation difficulties associated with the tremendous burden laid by the war upon the railroads, and in spite of the unavoidable inroads of the draft upon the labor supply. The result was attained only by unstinted effort on the part of all concerned—operators, employees, railroads, and consumers.

The production in 1918 was 56,478,372 tons, an increase of 871,544 tons over that in 1917, which had hitherto been the record year. The output of the beehive coke decreased 8 per cent, but the decrease was more than offset by an increase of 16 per cent in by-product coke. In spite of the inroads of the retort oven, however, beehive ovens continued to furnish the greater part of the coke produced. As shown in the accompanying diagram (fig. 130) the lines of beehive and by-product coke production are rapidly converging and will probably cross each other at no distant date, but up to the end of the war the line of beehive coke remained clearly in the lead. In terms of percentage of the total the proportions in 1918 were beehive 54 per cent, by-product 46 per cent.

It is not difficult to marshal the principal events of 1918 in the history of the coke trade. They may be read at a glance in the accompanying diagrams of operating conditions, which tell the story, week by week, like the rings of growth in the stump of a tree. Operations in the Connellsville region, shown in figure 131, may be taken as typical of the beehive industry. The depression in January and February, 1918, when the weekly output was less than half of the rated capacity, reflects the breakdown of transportation attendant on the unprecedented storms of that winter. So low did the output of coke fall during this period, and so great were the delays in delivering coke already shipped, that many iron furnaces were forced to bank for lack of coke, the production of pig fell off 25 per cent (fig. 132), and the success of the war program was threatened. By the use of priority orders attempts were made to supply the most urgent needs, but little could be accomplished in that direction when practically every ton of metallurgical coke available was already contributing to the war program. Throughout the first quarter of the year transportation was the dominant factor limiting production, but about April 1 the untiring efforts of the railroads, assisted by the Government, began to bear fruit, and production was raised to 67 per cent of the rated capacity. The improvement in car supply disclosed a growing shortage of coke-oven labor, which remained the limiting factor from then to the end of the year. Transportation continued to improve until, beginning with May 12, the ovens were furnished with cars for all the coke they could load. From the middle of May to the middle of August the car supply continued perfect, and although occasional reports of car shortage were received thereafter, at no time did the transportation loss amount to more than 5 per cent. In the meantime the coke workers in the Connellsville region, responding loyally to appeals for increased production, labored so well as to make up for the inroads of the draft. Strikes were practically nonexistent. The increase in labor losses shown for November and December was due largely to the epidemic of influenza.

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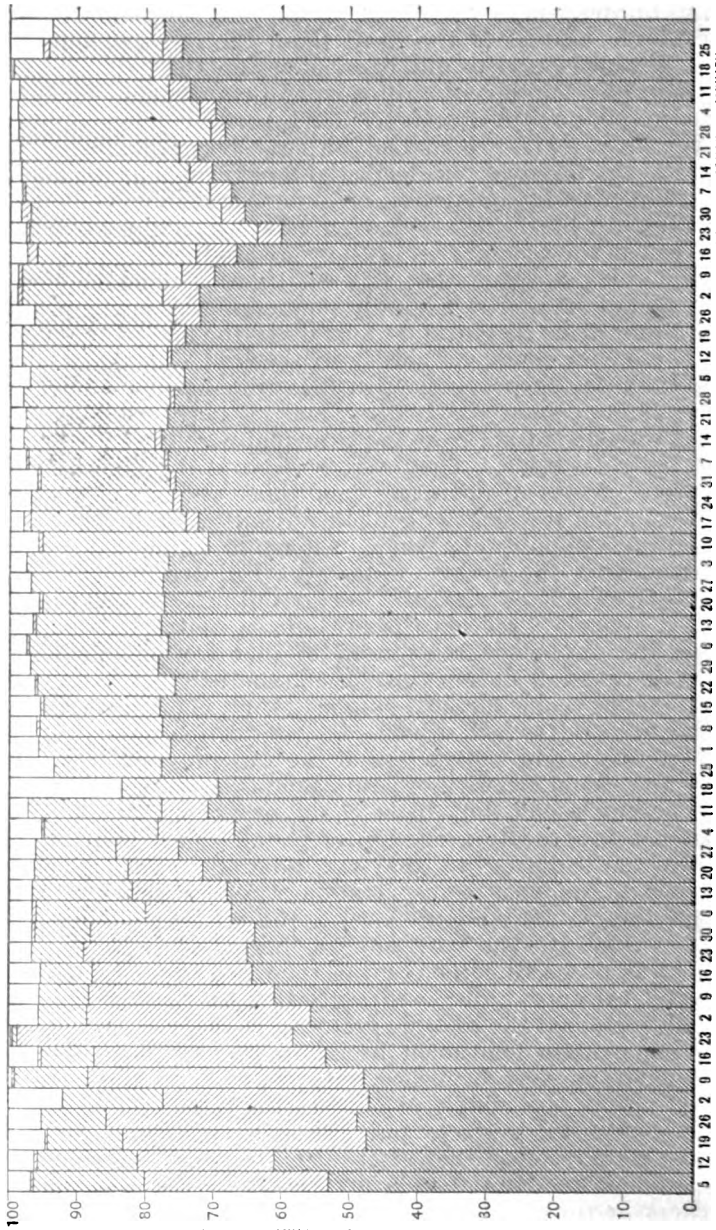

FIGURE 131.—Percentage of rated capacity produced and percentage "lost" from various causes in the Connellsville beehive-coke region, by weeks, January, 1918, to February 1, 1919.

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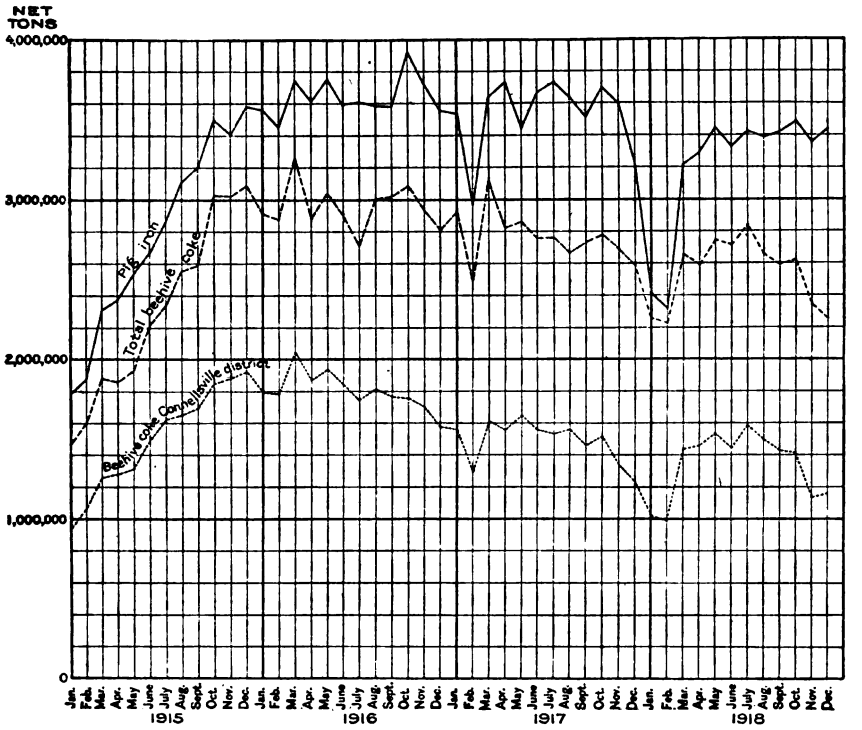

FIGURE 132.—Pig iron and beehive coke produced in the United States, by months, 1915–1918.

In the operation of the by-product plants also (fig. 133) transportation was the limiting factor early in 1918. Their difficulty was not lack of coke cars but delays in delivery of by-product coal. Stocks of high and low volatile coal at many by-product ovens in January fell to less than a week's supply. The week of minimum operation was January 13–19, when production fell to 67 per cent of capacity. The situation was especially critical because it involved a loss not only of coke but of the by-products needed for explosives. By the middle of March, however, improvement of transportation had so increased the reserves of coal on hand at the plants that an operation of 87 per cent was possible. By midsummer the limit of practicable operation, set by unavoidable breakdowns, had been reached and at this rate production was steadily maintained up to the time of the armistice, when a new factor—lack of demand—came into play. To make possible this maximum operation a reserve stock of by-product coal on hand at the plants sufficient to last five weeks was built up. In the meantime the construction of new by-product ovens was being pushed with all possible speed, and no month passed without material additions to the oven capacity of the country.

The success of the efforts to increase production may be judged from the fact that the output of all coke in October, 1918, was 5,169,000 tons, or at the rate of 62,000,000 tons a year.

On the day the armistice went into effect 718,000 tons of coke was on hand at blast furnaces, and out of 410 stacks only 2 were shut down for lack of coke.

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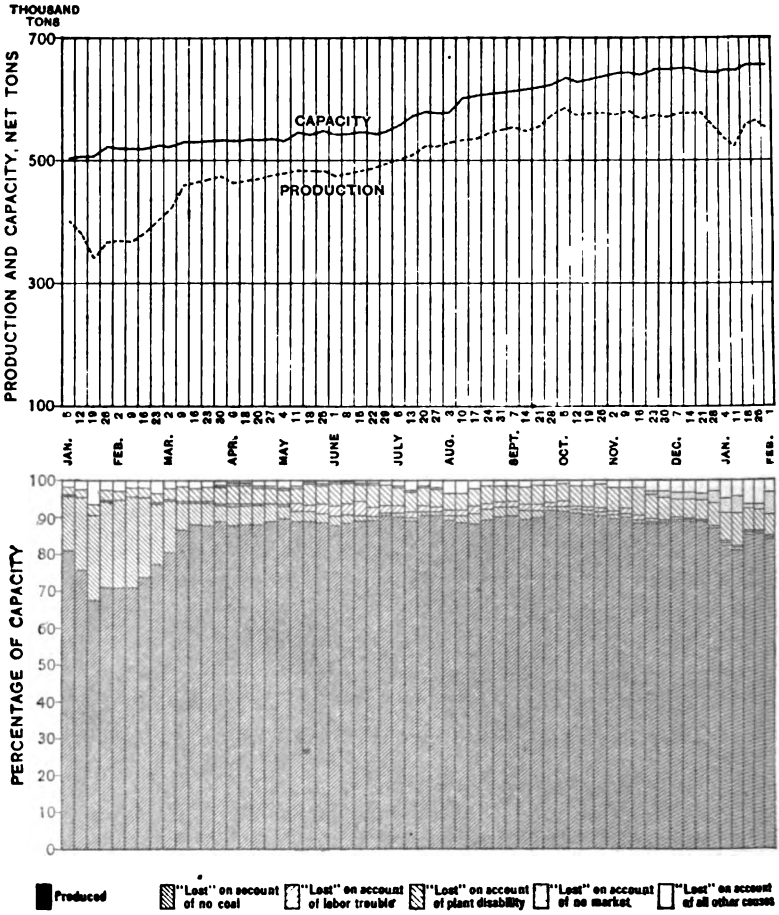

FIGURE 133.—By-product coke produced, maximum oven capacity, and operating conditions at the ovens, by weeks, January, 1918, to February 1, 1919.

During the year there was a decrease of 3,392, or 4 per cent, in the number of beehive ovens. By-product ovens, on the contrary, increased 1,410 in number and 25 per cent in capacity. New by-product plants were completed at Pueblo, Colo.; St. Paul, Minn.; Cleveland, Ironton, and Lorain, Ohio; and Clairton, Pa.; and additions to existing plants were made at Gary, Ind.; Sparrows Point, Md.; Youngstown, Ohio; Johnstown and Steelton, Pa.; and Chattanooga, Tenn. At the end of the year 1,815 other ovens were under construction.

Largely because of the unusual conditions surrounding the industry the average yield of coke from coal decreased. For beehive ovens it was 63.3 per cent; for by-product ovens 70.5 per cent.

The value of the products increased largely over that for 1917. Beehive coke at the ovens was valued at $189,000,000 and by-product coke at $193,000,000, a total of $382,000,000 for coke alone, as against $298,000,000 in 1917. The value of breeze and the several by-products brings the total for the industry as a whole in 1918 to $462,000,000.

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An increase in the quantity of by-products produced more than offset the effect of decreased prices for benzol and toluol. Sales of by-products amounted to $75,000,000, an increase of $10,000,000, or 15 per cent, over the sales in 1917. Striking testimony to the contribution of the industry to the manufacture of munitions is seen in the fact that of the crude light oils, the chief source from which benzol, the base of picric acid, and toluol, the base of TNT, are derived, the by-product coke ovens contributed 78 per cent.

THE COKE-PRODUCING INDUSTRIES.

Coke is produced in the United States by a group of four industries which are related in the sense that the product is more or less interchangeable, but which are sharply differentiated as to location, methods, equipment, and organization. Besides that produced in the familiar beehive and by-product ovens, coke is obtained in the refining of petroleum and in the manufacture of coal gas.

The petroleum coke may be dismissed with a word. In refining crude oil the ultimate residue left in the stills is a porous, carbonaceous solid, which is broken up into chunks and thrown out. Its properties are much like those of coke made from coal, except that it is finer in texture and lacks the strength required for metallurgical coke. The best petroleum coke is extraordinarily low in ash, running less than 1 per cent—a quality which adapts it to the manufacture of carbon electrodes. For this purpose it brings a high price—during the war as much as $18 a ton. Petroleum coke that can not meet the specifications for electrode manufacture is commonly used as boiler fuel about the refinery. The total quantity of petroleum coke produced in 1914, according to the census of manufactures, was 213,777 tons, valued at $818,889, an average of $3.83 a ton. In 1917 the output, according to statistics collected by the United States Bureau of Mines, had risen to 539,366 net tons; in 1918 it was 559,663 tons.

In the coal-gas industry, as in petroleum refining, the coke obtained is a by-product. The process of carbonization is essentially the same as that in by-product ovens, though the type of oven is very different. The coals used are selected for their yield in gas rather than for their coking qualities, and the coke formed is too soft for furnace or foundry use. It is, however, well adapted to the manufacture of water gas, a fact which has led to the common association of coal-gas and water-gas plants as parts of the same city supply. Indeed, of the 3,180,535 tons of gas-house coke produced in 1918, 43 per cent was used in water-gas manufacture or for boiler fuel about the plant where it was produced. The remainder, 1,814,000 tons, was marketed, largely as domestic fuel, for a total of $14,022,818.

Neither petroleum coke nor gas-house coke is adapted for metallurgical purposes—the use which consumes over 90 per cent of all the coke produced. Practically speaking, therefore, the coke trade is concerned only with beehive and by-product coke, and to them the statistics in this report are confined. Although their product is interchangeable, there are fundamental differences between the beehive and by-product industries which must not be lost sight of in examining the tables of this chapter. The manufacture of beehive coke is essentially a small-unit industry; that of by-product coke is a large-unit industry.

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In the beehive industry, the older of the two, the coal is charged into beehive-shaped or rectangular brick ovens of small capacity and burned with slight access to air, the heat required for coking being furnished by the combustion of the volatile matter and a part of the carbon. The beehive oven is well adapted to pioneering. It can be built in remote mining camps, wherever a seam of coking coal crops out, to supply an infant copper or iron industry. To avoid the cost of transportation on that part of the coal that is not converted into coke, the ovens are located at the mines. There is no recovery of by-products and no general market for the breeze or fines produced. The capital investment per oven is small, and the time required to construct an oven is brief. Each oven is a unit, and coke may be made on any scale, large or small. Although during the last 30 years there have been large consolidations of beehive operations, notably in the Connellsville district, the incentive to amalgamation was perhaps more the acquirement of reserves of coking coal than the unification of oven operation. The beehive oven is easily started up and as easily shut down. Deterioration from exposure to the elements is small and simply repaired. Producing coal of excellent quality for general use and therefore able to ship coal if not coke, the beehive operator is not confined to coke as his sole source of revenue. All these factors combine to make the overhead charges in beehive operation small and to adapt the industry to the fluctuating demand which has been a feature of American business.

In sharp contrast, the manufacture of by-product coke typifies large-scale modern industrialism. The by-product plant, with its intricately designed retort ovens, its use of power and machinery, its apparatus for by-product recovery, its tar and benzol stills, is essentially a chemical factory. It must be located near the point where the first among the by-products—the gas—is to be used, ordinarily near some large center of population. Not only are the volatile products in the gas recovered, but maximum efficiency in the utilization of fines and other wastes is possible. The by-product plant requires technical skill of the highest order, large initial investment, and large operating units. All these things mean heavy overhead expenses per ton of coke produced and put a premium on continuous operation.

The two industries have long been in competition. On the continent of Europe beehive coking went out of existence years ago, but in the United States it has persisted, although the good points of by-product ovens are as well known to the beehive operators as to anyone else. In fact, many of the active movers in by-product development have been financially allied with the companies that were producing beehive coke. Among the causes that have retarded the installation of retort ovens has been the small demand for many of the by-products in America. The ammonia could be easily marketed, but the lack of a dyestuffs industry in America meant small demand for the group of benzol products and low prices for tar. No less important was the absence of markets for gas near the chief centers of steel manufacture. In the Pittsburgh district by-product oven gas had to meet the competition of natural gas, which is superior in heating efficiency and for many years was available in unlimited quantity at exceedingly low prices. The very fact that the population is less dense in the United States than in Europe operated to discourage the

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recovery of by-products here. Moreover, the violent fluctuations in the production of iron and steel and consequently in the demand for coke, more marked in the United States than in Europe, were less of a handicap to the beehive industry, with its low overhead charges, than to the by-product plants, where continuous operation was essential to profits. Not least among these forces has been the prodigality of the Nation's resources in fuel, which made it cheaper to mine more coal than to use efficiently that already mined.

In the equilibrium between beehive and by-product manufacture an influence of great potentiality is the relative freight rate on coke and on raw coal. The average ton of beehive coke represents only 70 per cent of the weight of the coal necessary to make the same coke in a by-product oven. Therefore, merely to equalize transportation costs, beehive coke can stand a considerable freight differential in excess of coal. In recognition of this fact rates on coke have generally been higher than those on coal. Any disturbance of existing differentials between coal and coke rates would tend to alter the terms of competition between beehive and by-product coke.

CHANGE IN FORM OF INQUIRY IN 1918.

Certain changes in the form of inquiry used by the Geological Survey in 1918, which affect the comparability of some of the figures for 1918 with those for earlier years, should be borne in mind in examining the tables of this report. Prior to 1918 it had been the practice of the Geological Survey to ascertain the total quantity of coke produced, whether sold or used by the producer. No separate statement of sales was obtained, but instead a statement of the value of the entire product, including an estimate of the value of coke used but not sold. This form of inquiry was well adapted to the beehive-coke industry where the proportion of the output used by the producer was small. Applied to the growing by-product coke industry, however, it gave less and less satisfactory results. In the manufacture of by-product coke the bulk of the product is utilized by the operator and any figure of total value is naturally a matter of conjecture.

To obviate this difficulty the schedule used in 1918 was altered so as to ask separately for the quantity produced, the quantity sold, and the value of the quantity sold. (See reprint of schedules, p. 1524.) Where a measure of the total value of the entire output was required it has been estimated by the Geological Survey by assigning to that part of the output used by the operator an average value corresponding to the average of the sales reported for the same locality.

Still other changes were made in the inquiries concerning by-products. These had formerly asked for the quantity and value of "by-products obtained and sold," a form which sometimes failed to elicit the total production. The 1918 schedule asked for production, sales, and values of sales separately, and the figures are therefore not all comparable with those for 1917.

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The result of the new form of inquiry may be summarized as follows:

Beehive and by-product coke produced and sold in the United States in 1918.

	Beehive.	By-product.	Total.
Produced [a] ..... tons..	30,480,792	25,997,580	56,478,372
Sold:			
Furnace coke:			
Quantity ..... tons..	23,216,627	4,147,695	27,364,322
Value	$137,782,308	$30,792,247	$168,574,555
Foundry coke:			
Quantity ..... tons..	2,230,156	1,631,052	3,861,208
Value	$16,802,144	$15,849,017	$32,651,161
Domestic and other coke:			
Quantity ..... tons..	210,511	2,537,059	2,747,570
Value	$1,319,053	$18,907,079	$20,226,132
Total sales:			
Quantity ..... tons..	25,657,294	8,315,806	33,973,100
Value	$155,903,505	$65,548,343	$221,451,848
Used by producer ..... tons..	4,855,318	17,753,348	22,638,666
Estimated total value of coke produced [a]	$189,305,583	$193,018,785	$382,324,368

[a] Excluding breeze, of which 124,142 tons was produced at beehive coke plants and 1,999,370 tons at by-product plants, a total of 2,123,512 tons.

PRODUCTION.

SUMMARY.

The following tables summarize by States the principal facts concerning the beehive and by-product coke industries in 1917 and 1918. Certain of the States have only one or two producers, and returns from these operators are given in combinations in order not to disclose individual figures. Permission was requested and has been granted to publish as State totals the quantities reported for by-product coke in Colorado (1918 only), Kentucky, Maryland, Massachusetts, New Jersey, Tennessee, Washington, and West Virginia, and for beehive coke in Georgia and Ohio. Thanks are due to the officials of the companies in these States for this courtesy.

The total production of coke in 1918 was 56,478,372 tons, an increase over 1917 of 871,544 tons. The increase came entirely from by-product ovens, the output of which rose from 22,439,280 to 25,997,580 tons, a gain that more than counterbalanced a decline in the production from beehive ovens.

While the total output increased 1.6 per cent, the value—largely estimated—increased 28 per cent, rising from $298,000,000 to $382,000,000.

The summary table of production, by States (p. 1451), discloses clearly the localities in which the increase occurred. In terms of quantity Ohio led all other States, her increase amounting to 1,670,941 tons. In terms of percentage the greatest change was in New Jersey, where the construction of new by-product ovens late in 1917 was the cause of an increase of 61.1 per cent. Except in New Mexico, the output of beehive coke declined in every State, while that of by-product coke increased in all States but five—Alabama, Illinois, Kentucky, Maryland, and Massachusetts. Of the four States reporting an increase in total production of 200,000 tons or more—Ohio, Indiana, Minnesota, and New Jersey—all were outside the regions producing adequate quantities of coking coal. This is in accord with the tendency shown by the coke industry in recent years to migrate away from the mine, as by-product ovens located near the furnaces gradually replace beehive ovens at the mines.

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Coke produced in beehive and by-product coke ovens in the United States, 1917–18.

1917.

State.	Beehive coke.					By-product coke.					Total.			
	Active ovens.	Coal used (net tons).	Average yield (per cent).	Coke produced (net tons).	Value of coke at ovens.[a]	Active ovens.	Coal used (net tons).	Average yield (per cent).	Coke produced (net tons).	Value of coke at ovens.[a]	Coal used (net tons).	Coke produced (net tons).	Percentage to total production.	Value of coke at ovens.[a]
Alabama	5,493	3,659,598	58.8	2,151,828	$12,138,161	831	3,980,243	68.9	2,740,761	$16,256,111	7,638,841	4,892,589	8.8	$28,394,272
Colorado	2,867	1,784,631	62.3	1,112,449	5,479,734						1,784,631	1,112,449	2.0	5,479,734
Georgia	151	72,689	54.5	39,589	322,175						72,689	39,589	.1	322,175
Illinois						619	3,233,669	70.8	2,289,833	14,455,539	3,233,669	2,289,833	4.1	14,455,539
Indiana						861	4,817,942	73.5	3,540,718	21,831,302	4,817,942	3,540,718	6.4	21,831,302
Kentucky	801	599,626	55.3	331,532	1,794,315	108	742,162	71.6	531,539	2,324,948	1,341,788	863,071	1.6	4,119,263
Maryland						120	733,184	70.8	518,810	3,925,418	733,184	518,810	.9	3,925,418
Massachusetts						317	738,873	80.5	595,113	(b)	738,873	595,113	1.1	(b)
Minnesota						152	676,881	67.7	490,272	3,468,355	676,881	490,272	.9	3,468,355
New Jersey						260	621,699	68.1	423,361	(b)	621,699	423,361	.8	(b)
New Mexico	1,134	936,411	61.7	577,679	2,805,277						936,411	577,679	1.0	2,805,277
New York						615	1,401,458	70.9	993,184	6,889,424	1,401,458	993,184	1.8	6,889,424
Ohio	198	224,952	65.7	147,826	1,131,753	1,009	5,141,046	69.0	3,546,476	22,342,011	5,365,998	3,694,302	6.6	23,473,764
Pennsylvania	44,534	36,594,563	65.1	23,816,420	111,262,905	1,629	5,716,221	71.6	4,095,605	24,435,135	42,310,784	27,912,025	50.2	135,698,040
Tennessee	1,266	695,841	54.0	376,080	1,831,780	12	63,793	55.3	35,246	199,492	759,634	411,326	.7	2,031,272
Virginia	3,029	2,093,943	62.3	1,304,230	5,785,934						2,093,943	1,304,230	2.3	5,785,934
Washington	254	831,042	56.7	471,187	2,597,101	5	45,025	58.5	26,346	201,831	876,067	497,533	.9	2,798,932
Utah	726													
West Virginia	8,234	4,754,316	59.7	2,838,728	14,450,729	214	727,778	70.2	511,033	2,264,354	5,482,094	3,349,761	6.0	16,715,083
Michigan						258								
Missouri						56	2,865,785	73.3	2,100,983	c20,049,233	2,865,785	2,100,983	3.8	c 20,049,233
Wisconsin						232								
	68,687	52,246,612	63.5	33,167,548	159,599,864	7,298	31,505,759	71.2	22,439,280	138,643,153	83,752,371	55,606,828	100.0	298,243,017

[a] Includes estimates by operators for value of coke consumed in associated iron furnaces but not sold.
[b] Included in combined States.
[c] Includes also Massachusetts and New Jersey.

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Coke produced in beehive and by-product coke ovens in the United States, 1917–18—Continued.

1918.

State.	Beehive coke.					By-product coke.					Total.			
	Active ovens.	Coal used (net tons).	Average yield (per cent).	Coke produced (net tons).	Value of coke at ovens.[a]	Active ovens.	Coal used (net tons).	Average yield (per cent).	Coke produced (net tons).	Value of coke at ovens.[a]	Coal used (net tons).	Coke produced (net tons).	Percentage to total production.	Value of coke at ovens.[a]
Alabama	5,570	2,949,992	58.2	1,717,721	$13,973,660	807	3,877,634	67.9	2,634,451	$15,108,576	6,827,626	4,352,172	7.7	$29,082,236
Colorado	1,431	1,216,154	62.4	758,784	(b)	120	345,877	69.5	230,663	(b)	1,562,031	989,447	1.8	7,450,136
Georgia	101	38,280	57.6	22,048	193,317						38,280	22,048		193,317
Illinois						605	3,199,620	71.4	2,285,610	18,625,436	3,199,620	2,285,610	4.0	18,625,436
Indiana						945	5,318,900	73.3	3,898,215	31,462,493	5,318,900	3,898,215	6.9	31,462,493
Kentucky	798	533,346	56.4	301,036	1,798,389	108	723,113	73.9	517,749	2,657,606	1,256,459	818,785	1.4	4,455,995
Maryland						180	696,576	74.8	474,368	(b)	696,576	474,368	.8	(b)
Massachusetts						400	676,866	82.2	556,397	(b)	676,866	556,397	1.0	(b)
Michigan						269	(b)	75.9	(b)	(b)	(b)	(b)	(b)	(b)
Minnesota						214	1,069,775	73.3	784,065	6,806,468	1,069,775	784,065	1.4	6,806,468
Missouri						56	(b)	75.2	(b)	(b)	(b)	(b)	(b)	(b)
New Jersey						260	994,300	68.6	682,148	(b)	994,300	682,148	1.2	(b)
New Mexico	1,053	1,047,675	57.0	597,072	3,729,312						1,047,675	597,072	1.1	3,729,312
New York						615	1,516,580	70.5	1,069,587	9,920,419	1,516,580	1,069,587	1.9	9,920,419
Ohio	198	223,200	62.2	138,909	(b)	1,610	7,775,623	67.2	5,226,334	(b)	7,998,823	5,365,243	9.5	36,601,406
Oklahoma	304	(b)	58.2	(b)	(b)						(b)	(b)	(b)	(b)
Pennsylvania	37,730	34,059,026	65.0	22,136,664	130,739,138	2,189	6,514,868	70.4	4,586,981	29,618,136	40,573,894	26,723,645	47.3	160,357,274
Tennessee	1,101	564,920	53.1	302,637	2,156,591	24	166,157	74.9	124,469	1,020,023	731,077	427,106	.8	3,176,614
Utah	819	(b)	56.3	(b)	(b)						(b)	(b)	(b)	(b)
Virginia	3,135	2,042,429	60.4	1,234,256	8,046,115						2,042,429	1,234,256	2.2	8,046,115
Washington	250	154,460	60.6	93,659	910,459	20	47,410	74.8	30,129	286,226	201,870	123,788	.2	1,196,685
West Virginia	8,827	4,516,108	60.2	2,716,613	17,421,639	214	853,684	70.7	603,393	4,731,205	5,369,792	3,320,006	5.9	22,152,844
Wisconsin						268	(b)		(b)	(b)	(b)	(b)	(b)	(b)
Combined States		814,707		461,393	10,336,963		3,090,738		2,293,021	72,782,197	3,905,445	2,754,414	4.9	38,977,618
	61,317	48,160,297	63.3	30,480,792	189,305,583	8,904	36,867,721	70.5	25,997,580	193,018,785	85,028,018	56,478,372	100.0	382,324,368

[a] Includes estimates by Geological Survey for value of coke consumed in associated iron furnaces, but not sold, at prevailing prices of the coke sold.
[b] Included under "Combined States."

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Coke produced in the United States, 1914–1918, in net tons.

State.	1914	1915	1916	1917	1918	Increase or decrease, 1918.			
						Quantity.	Percentage.		
							Total.	Beehive.	By-product.
Alabama	3,084,149	3,071,811	4,298,417	4,892,589	4,352,172	− 540,417	−11.0	−20.2	− 3.9
Colorado	666,983	670,938	1,053,553	1,112,449	989,447	− 123,002	−11.1	−31.8	.....
Georgia	24,517	20,039	47,127	39,589	22,048	− 17,541	−44.3	−44.3	.....
Illinois	1,425,168	1,686,998	2,320,400	2,289,833	2,285,610	− 4,223	− .2	.....	− .2
Indiana	2,276,652	2,768,099	3,489,660	3,540,718	3,898,215	+ 357,497	+10.1	.....	+ 10.1
Kentucky	443,959	526,097	802,526	863,071	818,785	− 44,286	− 5.1	− 9.2	− 2.6
Maryland	87,852	313,283	489,982	518,810	474,368	− 44,442	− 8.6	.....	− 8.6
Massachusetts	540,631	504,438	563,048	595,113	556,397	− 38,716	− 6.5	.....	− 6.5
Michigan	(a)	(a)	(a)	(a)	(a)	(a)	(a)	.....	(a)
Minnesota	(a)	127,847	431,319	490,272	784,065	+ 293,793	+59.9	.....	+ 59.9
Missouri	.....	(a)	(a)	(a)	(a)	(a)	(a)	.....	(a)
New Jersey	255,283	269,448	210,766	423,361	682,148	+ 258,787	+61.1	.....	+ 61.1
New Mexico	362,572	389,411	502,812	577,679	597,072	+ 19,393	+ 3.4	+ 3.4	.....
New York	457,370	684,461	775,014	993,184	1,069,587	+ 76,403	+ 7.7	.....	+ 7.7
Ohio	521,638	684,658	1,803,268	3,694,302	5,365,243	+1,670,941	+45.2	− 6.0	+ 47.4
Oklahoma	.....	.....	.....	.....	(a)	(a)	(a)	(a)	.....
Pennsylvania	20,258,393	25,622,862	31,279,695	27,912,025	26,723,645	−1,188,380	− 4.3	− 7.1	+ 12.0
Tennessee	264,127	256,973	382,175	411,326	427,106	+ 15,780	+ 3.8	−19.5	+253.1
Utah	(a)	(a)	(b)	(b)	(a)	(a)	(a)	(a)	.....
Virginia	780,984	629,807	1,242,332	1,304,230	1,234,256	− 69,974	− 5.4	− 5.4	.....
Washington	84,923	136,552	c 534,653	c 497,533	123,788	+ 1,030	+ .8	− 2.9	+ 14.4
West Virginia	1,427,962	1,391,446	2,521,309	3,349,761	3,320,006	− 29,755	− .9	− 4.3	+ 18.1
Wisconsin	(a)	(a)	(a)	(a)	(a)	(a)	(a)	.....	(a)
Combined States	1,593,651	1,825,982	1,785,529	2,100,983	2,754,414	+ 278,656	+11.3	.....	.....
	34,555,914	41,581,150	54,533,585	55,606,828	56,478,372	+ 871,544	+ 1.6	− 8.1	+ 15.9

a Included under "Combined States." b Included with Washington. c Includes Utah.

BEEHIVE COKE.

The story of the beehive-coke industry during the last decade may be read from the following table of production, by States. From 1909 to 1917 the industry was virtually stationary. In the years of marked business activity it reached an annual output of 33 to 35 million tons; in dull years it dropped to 27 million tons, as in 1911 and 1915, or even to 23 million tons, as in 1914. The fluctuations in production during this period were more marked than those recorded in the by-product coke industry. The smaller capital investment per ton of output adapts the beehive industry to a position as an auxiliary source of coke supply, in contradistinction to the by-product industry, where heavy capital charges make steady operation essential.

The war demands for iron and steel called forth in 1916 a production of 35,464,000 tons of beehive coke, the maximum in the history of the industry. Thereafter competition of by-product ovens cut heavily into the output of beehive coke, which declined successively to 33,168,000 tons in 1917 and to 30,481,000 tons in 1918.

The most striking feature of the table is the position of dominance held by Pennsylvania in the beehive-coke industry. In the first year of the decade Pennsylvania produced 70 per cent of the total output; in the year of maximum production her proportion increased to 77 per cent, and even in 1918 it was 72.5 per cent of the total. If to the output of Pennsylvania is added that of the other States of the East, the dominance of the Appalachian region becomes even more apparent. The total production from the Western States in 1918 was 1,910,908 tons, or only 6.3 per cent of the total for the country.

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Beehive coke produced in the United States in 1909–1918, in net tons.

State.	1909	1910	1911	1912	1913	1914	1915	1916	1917	1918
Alabama	2,551,921	2,691,879	2,092,088	1,625,692	1,300,705	1,052,614	1,001,477	1,828,067	2,151,828	1,717,721
Colorado	1,072,562	1,199,248	951,748	972,941	879,461	666,083	670,938	1,053,553	1,112,449	758,784
Georgia	46,385	43,814	37,553	43,158	42,747	24,517	20,089	47,127	39,539	22,048
Illinois	(a)	(a)								
Indiana	(a)									
Kansas		(a)	(a)	(a)						
Kentucky	46,371	53,857	66,099	191,555	248,061	247,182	284,516	362,164	331,532	301,036
Montana	(a)	(a)								
New Mexico	373,967	401,646	381,927	413,906	467,945	362,572	389,411	502,812	577,679	597,072
Ohio	139,597	118,828	109,084	146,944	115,814	67,838	19,101	104,102	147,826	138,909
Oklahoma		(a)								(a)
Pennsylvania	23,056,134	24,262,634	20,430,426	25,464,074	26,124,764	18,074,057	22,530,567	27,159,438	23,816,420	22,136,664
Tennessee	261,808	322,756	330,418	370,076	364,578	264,127	233,705	329,702	376,080	302,637
Utah	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Virginia	1,347,478	1,493,655	910,411	967,947	1,303,603	780,984	629,807	1,242,332	1,304,230	1,234,256
Washington	42,981	59,337	40,180	(a)	(a)	(a)	(a)	(a)	(a)	93,659
West Virginia	3,857,555	3,725,873	2,125,950	2,277,613	2,336,600	1,381,675	1,250,235	2,327,502	2,338,728	2,716,613
Wisconsin	(a)	(a)	(a)							
Combined States	263,662	196,549	227,760	394,529	400,552	414,322	478,459	507,425	471,187	461,393
	33,060,421	34,570,076	27,703,644	32,868,435	33,584,830	23,335,971	27,508,255	35,464,224	33,167,548	30,480,792

a Included under "Combined States."

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A characteristic tendency of the decade has been the abandonment of beehive coking in districts remote from the mines. Ten years ago beehive ovens were being operated in Illinois, Indiana, Montana, and Wisconsin, generally on coal brought in from the East. Their output was small, and they served a local market. The competition of by-product coke speedily forced these local operators to the wall. The year 1909 saw the last beehive coke produced in Indiana; in 1910 the industry dropped out in Montana and Illinois; in 1911 it disappeared in Wisconsin.

It was not alone in these outlying States that the competition of by-product ovens affected the output. New by-product plants producing in 1918 cut into the demand for beehive coke in several States, notably in Pennsylvania, Ohio, Alabama, and Colorado.

The estimates in the two following tables are based not on statements from the operators, but on current reports of railroad shipments. The method employed in making the estimates is explained on page 1507. The estimates published currently from month to month or week to week were later revised to agree with the total production as ascertained by the mine canvass at the end of the year.

Beehive coke produced in the United States, 1915–1918, by months, in net tons.

[Estimated.]

Month.	1915	1916	1917	1918
January	1,445,691	2,919,002	2,923,056	2,255,578
February	1,583,992	2,887,349	2,489,888	2,225,098
March	1,864,922	3,263,196	3,138,977	2,651,829
April	1,841,369	2,875,600	2,813,935	2,590,868
May	1,936,414	3,043,940	2,861,364	2,743,271
June	2,209,666	2,917,543	2,754,397	2,712,790
July	2,345,271	2,721,323	2,753,902	2,834,714
August	2,553,055	2,999,220	2,649,755	2,651,829
September	2,581,708	3,015,848	2,727,367	2,590,867
October	3,029,077	3,079,332	2,780,436	2,621,348
November	3,024,698	2,933,921	2,677,284	2,347,021
December	3,092,392	2,807,950	2,596,687	2,255,579
	27,508,255	35,464,224	33,167,548	30,480,792

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Beehive coke produced in the United States in 1918, by weeks, in net tons.

[Estimated from railroad shipments.]

Week ended—		Week ended—	
Jan. 1–5 (5 days)	355,000	July 6	580,000
12	556,000	13	682,000
19	521,000	20	633,000
26	501,000	27	617,000
Feb. 2	469,000	Aug. 3	615,000
9	518,000	10	576,000
16	562,000	17	577,000
23	575,000	24	594,000
Mar. 2	623,000	31	610,000
9	597,000	Sept. 7	618,000
16	606,000	14	636,000
23	625,000	21	615,000
30	611,000	28	612,000
Apr. 6	570,000	Oct. 5	575,000
13	575,000	12	602,000
20	593,000	19	573,000
27	657,000	26	594,000
May 4	596,000	Nov. 2	560,000
11	626,000	9	560,000
18	636,000	16	553,000
25	622,000	23	522,000
June 1	583,000	30	523,000
8	662,000	Dec. 7	545,000
15	688,000	14	554,000
22	635,000	21	572,000
29	629,000	28	443,000
		29–31 (2 working days)	149,000
			30,481,000

The causes limiting production in the Connellsville region, the country's greatest center of beehive coke, are analyzed in the following table, based on reports received weekly from representative producers. Each operator was asked to report the rating of his plant and to apportion the quantity "lost"—that is, the quantity by which his output fell short of his capacity—among different causes interfering with capacity production. The percentages shown in the following table are weighted averages of these individual reports. They show clearly the particular cause restraining production in the particular week. It would be misleading, however, to add the percentages together and obtain an average for the year, because each set of percentages is based on the conditions prevailing at the moment, conditions which depended in turn on the situation in the weeks preceding. Thus the fact that during the first quarter of 1918 little or no labor shortage was reported means only that labor shortage as a cause limiting output was obscured by the more important cause of car shortage. Later, when the car shortage was eliminated, the scarcity of labor was disclosed and thenceforth became the limiting factor.

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Operating conditions in the beehive coke industry, as reported by representative operators in the Connellsville, Greensburg, and Latrobe districts, Pa.

Week ended—	Percentage produced.	Total "lost," all causes.	Percentage "lost" on account of—						
			No coke cars.	Labor shortage.		Strike.	Plant disability.	All other causes.	Cause not specified.
				Mine.	Yard.				
1917.									
Aug. 11	71.3	28.7	6.6	0.9	18.3	.....	0.4	2.1	0.4
18	70.2	29.8	5.6	2.0	19.6	.....	.....	2.1	.5
25	71.6	28.4	3.3	2.8	19.9	.....	.1	2.3	.....
Sept. 1	69.1	30.9	7.6	3.6	16.8	.....	.1	2.8	.....
8	73.0	27.0	4.6	1.6	18.0	.....	.1	2.7	.....
15	73.7	26.3	6.6	.....	16.8	.....	.....	2.9	.....
22	70.5	29.5	10.6	1.6	14.8	.....	.....	2.5	.....
29	68.4	31.6	10.7	4.5	14.2	.....	.....	2.2	.....
Oct. 6	72.7	27.3	5.5	2.5	17.2	.....	.1	2.0	.....
13	68.2	31.8	9.6	2.8	18.9	.....	.....	.5	.....
20	69.8	30.2	8.7	1.4	20.1	.....	.....	.....	.....
27	67.0	33.0	10.6	1.8	20.4	.....	.....	.2	.....
Nov. 3	65.4	34.6	16.0	2.2	14.2	.....	.....	2.2	.....
10	68.0	32.0	13.2	2.2	13.9	.....	.1	2.6	.....
17	66.4	33.6	16.2	1.2	12.8	0.7	.....	2.7	.....
24	65.6	34.4	15.6	2.4	13.6	.....	.3	2.5	.....
Dec. 1	62.6	37.4	23.5	1.8	9.3	.1	.....	2.7	.....
8	70.2	29.8	16.6	1.8	9.3	.1	.....	2.0	.....
15	49.5	50.5	36.0	.4	11.1	.1	.....	2.9	.....
22	56.8	43.2	29.6	1.2	9.5	.1	.....	2.8	.....
29	63.9	36.1	16.3	1.3	15.1	.4	.....	3.0	.....
1918.									
Jan. 5	53.0	47.0	27.1	.9	15.6	.....	.1	3.3	.....
12	61.0	39.0	20.2	1.0	13.5	.....	.4	3.9	.....
19	47.4	52.6	35.8	1.1	10.0	.....	.1	5.6	.....
26	48.6	51.4	37.2	.7	8.7	.....	.4	4.4	.....
Feb. 2	47.0	53.0	30.5	.....	14.9	.....	.....	7.6	.....
9	47.8	52.2	40.5	.....	11.0	.....	.3	.4	.....
16	53.2	46.8	34.4	.1	7.9	.....	.1	4.3	.....
23	58.1	41.9	32.7	.....	8.9	.....	.1	.2	.....
Mar. 2	55.0	45.0	34.0	.2	6.9	.....	.1	3.8	.....
9	60.7	39.3	27.8	.8	6.3	.....	.1	4.3	.....
16	64.1	35.9	23.8	.7	6.5	.....	.....	4.9	.....
23	65.6	34.4	23.4	.6	6.5	.....	.1	3.8	.....
30	63.7	36.3	24.3	.2	8.1	.....	.2	3.5	.....
Apr. 6	67.2	32.8	12.8	.6	15.4	.....	.6	3.4	.....
13	67.8	32.2	13.9	.7	13.7	.....	.....	3.9	.....
20	71.6	28.4	10.9	.4	13.3	.....	.....	3.8	.....
27	75.2	24.8	8.6	.6	11.5	.....	.....	4.1	.....
May 4	70.4	29.6	6.3	1.5	18.2	.....	3.6	.....	.....
11	70.7	29.3	6.8	19.4		.....	.3	2.8	.....
18	69.2	30.8	.....	14.4		.....	.....	16.4	.....
25	77.0	23.0	.4	15.4		.....	.....	7.2	.....
June 1	75.6	24.4	.8	18.4		.....	.....	5.2	.....
8	77.2	22.8	.5	18.3		.....	.2	3.8	.....
15	77.2	22.8	.8	17.8		.....	.3	3.9	.....
22	75.5	24.5	.5	20.5		.....	.2	3.3	.....
29	77.4	22.6	.6	19.2		.....	.....	2.8	.....
July 6	77.1	22.9	.3	20.1		.....	.1	2.4	.....
13	77.2	22.8	.5	18.8		.....	.4	3.1	.....
20	76.6	23.4	.4	18.7		.....	.3	4.0	.....
27	76.6	23.4	.5	20.2		.....	.....	2.7	.....
Aug. 3	76.1	23.9	.5	21.1		.....	.....	2.3	.....
10	70.3	29.7	.6	24.9		.....	.2	4.0	.....
17	71.7	28.3	2.5	23.0		.....	.9	1.9	.....
24	74.6	25.4	1.2	21.2		.....	.....	3.0	.....
31	75.1	24.9	1.2	19.6		.....	.1	4.0	.....
Sept. 7	76.2	23.8	1.0	20.3		.....	.1	2.4	.....
14	77.8	22.2	.4	19.0		.....	.1	2.7	.....
21	76.7	23.3	.6	20.5		.....	.1	2.1	.....
28	76.4	23.6	1.0	20.5		.....	.1	2.0	.....
Oct. 5	75.5	24.5	.5	21.6		.....	.....	2.4	.....
12	77.0	23.0	.9	20.7		.....	.....	1.4	.....
19	75.1	24.9	2.5	20.9		.....	.....	1.5	.....
26	73.9	26.1	3.8	19.2		.....	.....	3.1	.....
Nov. 2	73.1	26.9	5.0	20.4		.....	.4	1.1	.....
9	69.6	30.4	4.8	24.2		.....	.4	1.0	.....
16	66.4	33.6	5.5	24.8		.....	1.3	2.0	.....
23	60.4	39.6	3.2	34.0		.....	.2	2.2	.....
30	65.6	34.4	3.0	29.0		.....	1.0	1.4	.....

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Operating conditions in the beehive coke industry, as reported by representative operators in the Connellsville, Greensburg, and Latrobe districts, Pa.—Continued.

Week ended—	Percentage produced.	Total "lost," all causes.	Percentage "lost" on account of—						
			No coke cars.	Labor shortage.		Strike.	Plant disability.	All other causes.	Cause not specified.
				Mine.	Yard.				
1918.									
Dec. 7	66.6	33.4	3.2	28.9				1.3	
14	70.2	29.8	3.0	25.9				.9	
21	73.0	27.0	2.5	23.6				.9	
28	68.2	31.8	1.9	29.1				.8	
1919.									
Jan. 4	70.4	29.6	2.0	26.8				.8	
11	72.6	27.4	2.8	23.7				.9	
18	76.0	24.0	2.6	21.0				.4	
25	74.6	25.4	2.6	17.1			0.7	5.0	
Feb. 1	75.2	24.8	1.5	15.9				7.4	

BY-PRODUCT COKE.

SUMMARY.

Two tendencies are disclosed by the statistics of by-product coke production during the decade 1909–1918, shown in the following table. The first is the sharp rise in total production from 6,255,000 tons in 1909 to 25,998,000 tons in 1918, an increase of more than fourfold. In the first five years of the period the output doubled. In the next five years it doubled again.

No less significant, although less apparent, was the westward migration of the industry, toward the industrial centers of the Central States, with their demand for iron and steel products, and away from the fields that produce coking coal. In 1909 Pennsylvania was the largest producer, contributing 30 per cent of the output. At that time the by-product industry was already planted in the States to the north and east of the coal fields—New England, New Jersey, New York, and Maryland—all of which were producing substantial quantities of by-product coke in 1909. Toward the West the industry was established in Illinois and Wisconsin and had made a small beginning in Ohio. Alabama reported a scant half million tons in 1909. During the next 10 years State after State in the West was added to the ranks of by-product producers. Production began in Indiana in 1910, in Washington in 1914, in Missouri in 1915, and in Colorado in 1918. A notable development in the Mahoning Valley and other districts in Ohio carried the production in that State from 83,000 tons in 1909 to 5,226,000 tons in 1918. This made Ohio the leading producer. The migration of the by-product industry toward the centers of consumption may be summed up in the statement that from 1909 to 1918 the production in States that contain deposits of by-product coal increased three and one-third times, while production in States that mine no by-product coal increased nearly five times.

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By-product coke produced in the United States, 1909–1918, in net tons.

State.	1909	1910	1911	1912	1913	1914	1915	1916	1917	1918
Alabama	533,903	557,148	669,433	1,349,797	2,022,959	2,031,535	2,070,334	2,470,350	2,740,761	2,634,451
Colorado										230,663
Illinois	1,276,404	1,513,126	1,610,212	1,764,944	1,859,553	1,425,168	1,686,998	2,320,400	2,289,833	2,285,610
Indiana		84,046	916,411	2,616,339	2,727,025	2,276,652	2,768,099	3,489,660	3,540,718	3,398,215
Kentucky					69,023	196,777	241,581	440,362	531,539	517,749
Maryland	315,587	335,373	343,451	304,715	236,423	87,852	313,283	489,982	518,810	474,368
Massachusetts	444,349	450,001	477,564	511,596	531,384	540,631	504,438	563,048	595,113	556,397
Michigan	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Minnesota	(a)	(a)	(a)	(a)	(a)	(a)	127,847	431,319	490,272	784,065
Missouri							(a)	(a)	(a)	(a)
New Jersey	261,460	250,153	255,334	304,715	255,792	255,283	269,448	210,766	423,361	682,148
New York	523,551	652,459	686,172	794,618	758,486	457,370	684,461	775,014	993,184	1,069,587
Ohio	83,114	163,487	202,298	241,725	236,032	453,800	665,557	1,699,166	3,546,476	5,226,334
Pennsylvania	1,849,391	2,052,973	1,493,509	1,974,619	2,628,680	2,184,336	3,092,295	4,120,257	4,095,605	4,586,981
Tennessee							23,208	52,473	35,246	124,469
Washington						(a)	(a)	27,228	26,346	30,129
West Virginia	86,393	77,977	165,099	188,373	136,152	46,287	141,211	193,807	511,033	603,393
Wisconsin	463,904	528,660	577,619	578,875	645,822	(a)	(a)	(a)	(a)	(a)
Combined States	416,588	473,331	450,743	484,848	607,369	1,264,252	1,484,075	1,785,529	2,100,983	2,293,021
	6,254,644	7,138,734	7,847,845	11,115,164	12,714,700	11,219,943	14,072,895	19,069,361	22,439,280	25,997,580

a Included under "Combined States."

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FACTORS LIMITING THE PRODUCTION OF BY-PRODUCT COKE.

The monthly production of by-product coke from January, 1917, to December, 1918, is shown in the accompanying table, based on current reports from the operators. The table shows the gradual increase in output attendant on the construction of new ovens. What it fails to bring out is the relation between production and capacity, a subject which is analyzed in the tables on pages 1459–1473. These tables are based on weekly reports from by-product plants made to the United States Fuel Administration and the Geological Survey. The reports were designed to enable the Fuel Administration to keep its finger on the pulse of the by-product industry as a source of the most necessary of war materials. So great was the demand for both coke and benzol products that maximum operation of all existing plants was a military necessity. The system of reports resembled that used in connection with beehive coke and bituminous coal. Each operator was requested to state the maximum weekly capacity of his plant and the coke produced and to apportion among specified causes the quantity of coke "lost." The records were essentially operating statistics, but they have historical value also. It is significant that even under the conditions of forced operation which prevailed in 1918 the by-product plants of the country seldom averaged more than 90 per cent of their maximum capacity, defined as the "maximum quantity of coke of the grade regarded as standard which can be produced with all ovens active when all conditions are favorable." It is difficult to imagine conditions more favorable than those existing late in the summer of 1918, yet the best performance attained in any one week was 92.2 per cent of capacity, recorded in the last week of September. The causes curtailing output in that week were plant disability, no coal, and labor trouble, to which losses of 4.7, 1.2, and 1 per cent, respectively, were attributed.

These data are of great significance in forecasting the quantity of coke that can be produced from a given equipment of ovens. They show clearly that under existing conditions in the United States an average operation of more than 90 per cent is exceptional, and that in calculating the capacity of the country's equipment of plants for either coke or by-products an average operation in excess of 90 per cent should not be assumed.[1]

By-product coke produced in the United States, 1917 and 1918, by months, in net tons.

Month.	1917	1918
January	1,787,850	1,637,848
February	1,806,773	1,533,857
March	1,813,435	2,027,811
April	1,859,278	2,001,514
May	1,879,268	2,105,804
June	1,890,335	2,079,806
July	1,882,200	2,287,787
August	1,914,450	2,365,780
September	1,918,714	2,301,777
October	1,898,192	2,547,763
November	1,899,526	2,495,768
December	1,899,250	2,521,765
	22,439,280	25,907,880

[1] The data in these tables are shown graphically in the report of the distribution division of the United States Fuel Administration, Part I, "The distribution of coal and coke," pp. 77–83.

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By-product coke produced in the United States and in several States, 1918, by weeks.

United States.

Week ended—	Coal charged (net tons).	Maximum weekly capacity (net tons).	Coke produced.		Percentage of coke "lost" on account of—					
			Quantity (net tons).	Percentage of capacity.	Total.	No coal.	Labor trouble.	Plant disability.	No demand.	Other causes.
Jan. 5	561,216	505,234	407,742	80.7	19.3	15.0	0.2	2.2	.....	1.9
12	533,812	507,545	382,816	75.4	24.6	20.0	.....	2.1	.....	2.5
19	480,196	507,606	341,269	67.0	33.0	23.4	.....	2.9	.....	6.7
26	515,351	524,279	370,853	70.7	29.3	23.7	.1	2.8	.....	2.7
Feb. 2	518,038	523,256	370,428	70.8	29.2	23.9	.....	2.7	.....	2.6
9	514,625	521,188	369,475	70.9	29.1	24.8	.....	2.3	.....	2.0
16	540,040	521,501	383,939	73.6	26.4	21.8	.....	2.4	.....	2.2
23	572,427	525,230	405,096	77.1	22.9	16.8	.1	2.5	.....	3.5
Mar. 2	596,413	524,804	422,028	80.4	19.6	14.0	.1	3.2	.....	2.3
9	640,737	530,691	458,492	86.4	13.6	7.8	.2	3.6	.....	2.0
16	646,286	531,263	466,307	87.8	12.2	6.4	.2	3.3	.....	2.3
23	654,125	536,016	469,591	87.6	12.4	6.6	.1	4.1	.....	1.6
30	651,777	534,638	473,563	88.6	11.4	5.0	.1	4.9	0.2	1.2
Apr. 6	645,227	532,826	466,047	87.5	12.5	5.1	1.1	5.3	.3	.7
13	648,328	533,982	469,536	87.9	12.1	5.5	.5	5.2	.3	.6
20	657,483	535,068	471,015	88.0	12.0	5.7	.1	4.5	.3	1.4
27	663,384	536,881	477,102	88.9	11.1	5.0	.....	4.6	.3	1.2
May 4	672,733	537,501	480,355	89.4	10.6	3.7	.6	4.7	.3	1.3
11	675,827	546,349	486,383	89.0	11.0	2.8	2.3	4.7	.3	.9
18	675,519	545,925	486,131	89.0	11.0	2.7	2.0	5.6	.3	.4
25	675,927	547,405	484,402	88.5	11.5	2.6	2.6	4.9	.2	1.2
June 1	670,689	546,934	479,723	87.7	12.3	2.8	3.0	5.4	.3	.8
8	671,717	546,919	481,997	88.1	11.9	2.7	3.0	5.3	.2	.7
15	673,475	547,470	484,290	88.5	11.5	2.7	3.0	5.0	.1	.7
22	679,116	546,973	489,239	89.4	10.6	1.0	2.6	6.1	.1	.8
29	688,867	548,382	496,227	90.5	9.5	.9	2.0	5.5	.....	1.1
July 6	699,995	556,592	502,666	90.3	9.7	.8	2.2	5.2	.1	1.4
13	715,655	573,699	511,283	89.1	10.9	.8	1.9	5.3	.1	2.8
20	728,955	577,300	524,410	90.8	9.2	.9	1.8	4.8	.1	1.6
27	729,857	578,276	523,899	90.6	9.4	.9	1.8	4.9	.1	1.7
Aug. 3	747,782	596,801	532,876	89.3	10.7	1.0	1.8	4.4	.....	3.5
10	747,496	602,434	533,835	88.6	11.4	1.8	1.8	4.4	.....	3.4
17	759,262	607,541	536,323	88.3	11.7	2.9	2.2	4.6	.....	2.0
24	766,182	609,634	545,341	89.5	10.5	2.9	1.4	4.8	.....	1.4
31	771,720	611,734	550,921	90.1	9.9	2.9	1.4	4.3	.....	1.3
Sept. 7	779,835	614,696	556,401	90.5	9.5	2.5	1.5	4.0	.....	1.5
14	780,469	618,830	553,371	89.4	10.6	2.5	1.9	4.9	.....	1.3
21	784,765	620,199	557,550	89.9	10.1	2.1	1.6	5.2	.....	1.2
28	807,282	624,910	576,055	92.2	7.8	1.2	1.0	4.7	.....	.9
Oct. 5	819,927	636,820	585,337	91.9	8.1	1.3	1.3	4.8	.....	.7
12	805,257	628,289	573,743	91.3	8.7	1.1	.6	5.3	.....	1.7
19	816,029	635,179	578,027	91.0	9.0	1.3	.6	5.7	.....	1.4
26	815,495	639,881	580,667	90.7	9.3	1.1	1.0	6.2	.....	1.0
Nov. 2	815,432	644,419	578,079	89.7	10.3	1.1	1.1	6.3	.....	1.8
9	824,418	645,668	581,478	90.1	9.9	1.0	1.4	5.7	.....	1.8
16	810,894	644,040	570,497	88.6	11.4	1.0	1.0	7.4	.....	2.0
23	810,459	650,314	575,685	88.5	11.5	.5	.8	6.7	.7	2.8
30	808,730	650,784	573,674	88.2	11.8	.4	.7	6.0	1.8	2.9
Dec. 7	807,306	651,806	578,084	88.7	11.3	.7	.7	5.2	2.0	2.7
14	814,489	651,837	577,747	88.6	11.4	.5	.3	5.3	2.1	3.2
21	816,880	650,707	577,247	88.7	11.3	.3	.5	5.4	1.7	3.4
28	794,916	646,645	559,707	86.6	13.4	.2	.5	6.1	3.2	3.4
Total 52 weeks.	36,502,822	30,014,901	26,068,949	86.9	13.1	5.1	1.1	4.7	.3	1.9

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By-product coke produced in the United States and in several States, 1918, by weeks—Continued.

Alabama.

Week ended--	Coal charged (net tons).	Maximum weekly capacity (net tons).	Coke produced.		Percentage of coke "lost" on account of—					
			Quantity (net tons).	Percentage of capacity.	Total.	No coal.	Labor trouble.	Plant disability.	No demand.	Other causes.
Jan. 5	75,270	59,231	53,193	89.8	10.2	1.6	.....	.....	.....	8.6
12	75,418	59,273	53,684	90.6	9.4	1.2	.....	.....	.....	8.2
19	70,438	59,273	48,504	81.8	18.2	4.0	.....	.....	.....	14.2
26	74,874	59,273	52,917	89.3	10.7	4.2	.....	0.8	.....	5.7
Feb. 2	76,040	59,273	53,472	90.2	9.8	3.3	.....	1.5	.....	5.0
9	74,417	59,273	52,495	88.6	11.4	3.1	.....	1.7	.....	6.6
16	72,159	56,946	50,734	89.1	10.9	2.9	.....	2.2	.....	5.8
23	70,640	59,273	49,973	84.3	15.7	9.4	.....	.6	.....	5.7
Mar. 2	67,818	59,273	44,083	74.4	25.6	19.3	.....	2.4	.....	3.9
9	70,897	59,273	49,683	83.8	16.2	4.8	.....	3.8	.....	7.6
16	72,782	59,273	51,113	86.2	13.8	4.2	.....	2.9	.....	6.7
23	74,651	59,273	50,954	86.0	14.0	7.2	.....	1.5	.....	5.3
30	73,176	59,273	52,070	87.8	12.2	1.6	.....	4.5	.....	6.1
Apr. 6	73,623	59,273	52,109	87.9	12.1	1.1	.....	11.0	.....	.....
13	72,068	59,273	52,155	88.0	12.0	1.4	.....	10.6	.....	.....
20	73,121	59,273	51,919	87.6	12.4	.9	.....	4.7	.....	6.8
27	74,642	59,273	53,043	89.5	10.5	1.1	.....	3.6	.....	5.8
May 4	76,666	59,273	52,451	88.5	11.5	1.2	.....	5.5	.....	4.8
11	77,418	59,273	53,978	91.1	8.9	1.1	.....	3.1	.....	4.7
18	73,506	59,273	51,924	87.6	12.4	1.2	.....	11.2	.....	.....
25	74,595	59,273	52,320	88.3	11.7	1.3	.....	4.9	.....	5.5
June 1	73,456	59,273	51,263	86.5	13.5	1.4	.....	10.6	.....	1.5
8	72,216	59,273	50,998	86.0	14.0	.9	.....	10.0	.....	3.1
15	74,601	59,273	52,244	88.1	11.9	1.0	.....	8.6	.....	2.3
22	70,438	59,273	49,725	83.9	16.1	.5	.....	12.2	.....	3.4
29	73,164	59,273	51,532	86.9	13.1	.....	.....	9.5	.....	3.6
July 6	72,741	59,375	51,219	86.3	13.7	.....	.....	9.8	.....	3.9
13	72,169	59,375	51,066	86.0	14.0	.....	.....	10.1	.....	3.9
20	72,294	59,365	51,992	87.6	12.4	.....	.....	10.6	.....	1.8
27	71,955	59,515	51,847	87.1	12.9	.....	.....	11.0	.....	1.9
Aug. 3	73,124	59,744	52,653	88.1	11.9	.....	.....	9.7	.....	2.2
10	75,610	59,911	53,308	89.0	11.0	.....	.....	8.5	.....	2.5
17	73,990	59,961	52,694	87.9	12.1	.....	.....	9.4	.....	2.7
24	73,627	59,961	53,358	89.0	11.0	.....	.....	11.0	.....	.....
31	75,799	59,961	53,999	90.1	9.9	.....	.....	8.2	.....	1.7
Sept. 7	75,114	60,045	53,533	89.2	10.8	.....	.....	6.8	.....	4.0
14	75,833	59,899	53,350	89.1	10.9	.....	.....	10.9	.....	.....
21	74,584	59,768	52,719	88.2	11.8	.....	.....	11.7	.....	.1
28	74,437	59,668	52,855	88.6	11.4	.....	.....	11.4	.....	.....
Oct. 5	73,766	59,676	51,896	87.0	13.0	.....	.....	13.0	.....	.....
12	75,045	60,015	51,636	86.0	14.0	.....	.....	14.0	.....	.....
19	74,984	59,948	51,148	85.3	14.7	.....	.....	14.7	.....	.....
26	72,673	59,948	51,172	85.4	14.6	.....	.....	14.6	.....	.....
Nov. 2	72,399	60,084	51,152	85.1	14.9	.....	.....	14.9	.....	.....
9	73,701	60,057	52,077	86.7	13.3	.....	.....	13.3	.....	.....
16	69,426	60,061	45,920	76.5	23.5	.....	.....	23.5	.....	.....
23	69,157	60,061	47,850	79.7	20.3	.....	.....	12.0	.....	8.3
30	70,457	60,061	47,903	79.8	20.2	.....	.....	12.5	.....	7.7
Dec. 7	67,763	60,061	46,044	76.7	23.3	.....	.....	14.7	.....	8.6
14	70,834	60,061	49,770	82.9	17.1	.....	.....	17.0	.....	.1
21	70,562	60,061	49,428	82.3	17.7	.....	.....	17.7	.....	.....
28	64,622	60,061	45,748	76.2	23.8	.....	.....	23.8	.....	.....
Total 52 weeks	3,794,760	3,095,432	2,664,873	86.1	13.9	1.5	.....	8.9	.....	3.5

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By-product coke produced in the United States and in several States, 1918, by weeks—Continued.

Illinois.

Week ended—	Coal charged (net tons).	Maximum weekly capacity (net tons).	Coke produced.		Percentage of coke "lost" on account of—					
			Quantity (net tons).	Percentage of capacity.	Total.	No coal.	Labor trouble.	Plant disability.	No demand.	Other causes.
Jan. 5	45,319	48,851	32,112	65.7	34.3	33.6	0.6	0.1	.....	.....
12	42,116	48,851	30,197	61.8	38.2	37.1	.....	.....	.....	1.1
19	33,769	48,851	21,539	44.1	55.9	41.0	.....	.1	.....	14.8
26	41,571	48,851	29,250	59.9	40.1	38.6	.....	.....	.....	1.5
Feb. 2	45,579	49,798	31,955	64.2	35.8	35.8	.....	.....	.....	.....
9	43,505	49,798	31,553	63.4	36.6	33.8	.....	.....	.....	2.8
16	47,440	49,798	33,651	67.6	32.4	30.8	.....	.....	.....	1.6
23	53,405	49,798	36,995	74.3	25.7	22.8	.....	.....	.....	2.9
Mar. 2	60,022	49,798	41,938	84.2	15.8	12.2	.....	.....	.....	3.6
9	63,803	49,798	45,028	90.4	9.6	6.1	.....	3.0	.....	.5
16	63,750	49,798	45,164	90.7	9.3	8.7	.....	.1	.....	.5
23	63,931	49,798	44,931	90.2	9.8	5.1	.....	4.3	.....	.4
30	64,101	49,798	45,812	92.0	8.0	4.0	.....	3.6	.....	.4
Apr. 6	63,607	49,798	46,051	92.5	7.5	4.2	.....	2.7	.....	.6
13	64,088	49,798	46,277	92.9	7.1	4.0	.....	2.5	.....	.6
20	64,455	49,798	46,245	92.9	7.1	5.0	.....	1.6	.....	.5
27	64,255	49,798	45,590	91.5	8.5	5.1	.....	2.8	.....	.6
May 4	64,812	49,798	44,848	90.1	9.9	5.0	.....	4.3	.....	.6
11	64,244	49,798	44,878	90.1	9.9	3.6	.....	5.9	.....	.4
18	64,784	49,798	45,522	91.4	8.6	2.9	.....	5.3	.....	.4
25	66,362	49,798	46,183	92.7	7.3	2.4	.....	4.3	.....	.6
June 1	65,117	49,798	45,994	92.4	7.6	3.0	.....	4.2	.....	.4
8	66,531	49,798	45,929	92.2	7.8	3.5	.....	3.9	.....	.4
15	66,181	49,798	46,232	92.8	7.2	4.0	.....	2.7	.....	.5
22	65,150	48,398	45,942	94.9	5.1	1.0	.....	3.7	.....	.4
29	64,745	48,398	45,930	94.9	5.1	1.3	.....	3.5	.....	.3
July 6	64,951	48,398	46,526	96.1	3.9	1.5	.....	1.7	.....	.7
13	65,389	48,398	45,206	93.4	6.6	1.6	.....	4.5	.....	.5
20	65,168	48,398	46,439	96.0	4.0	1.6	.....	1.7	.....	.7
27	65,244	48,398	46,684	96.5	3.5	1.6	.....	1.0	.....	.9
Aug. 3	65,080	48,528	46,403	95.6	4.4	1.8	.....	1.4	.....	1.2
10	64,002	48,398	45,239	93.5	6.5	2.9	.....	2.8	.....	.8
17	62,214	48,398	43,781	90.5	9.5	5.9	.....	2.9	.....	.7
24	62,292	48,398	44,114	91.1	8.9	6.4	.....	1.7	.....	.8
31	62,719	48,398	45,006	93.0	7.0	5.6	.....	.5	.....	.9
Sept. 7	64,477	50,097	48,007	95.8	4.2	3.2	.....	.1	.....	.9
14	64,541	49,300	45,358	92.0	8.0	2.8	.....	4.2	.....	1.0
21	64,795	49,400	44,839	90.8	9.2	2.6	.....	5.9	.....	.7
28	65,351	49,400	46,985	95.1	4.9	2.2	.....	1.9	.....	.8
Oct. 5	66,460	49,440	46,965	95.0	5.0	1.8	.....	2.5	.....	.7
12	66,437	49,440	47,034	95.1	4.9	1.4	.....	2.8	.....	.7
19	66,503	49,440	47,441	96.0	4.0	1.2	.....	2.1	.....	.7
26	64,546	49,440	45,529	92.1	7.9	1.6	2.0	3.5	.....	.8
Nov. 2	64,644	49,440	44,810	90.6	9.4	2.2	2.0	4.4	.....	.8
9	64,466	49,440	44,692	90.4	9.6	1.9	2.0	5.0	.....	.7
16	64,526	49,440	45,575	92.2	7.8	1.6	1.6	3.7	.....	.9
23	64,999	49,440	46,870	94.8	5.2	.....	.....	3.4	.....	1.8
30	65,104	49,440	46,367	93.8	6.2	.....	.....	5.4	.....	.8
Dec. 7	65,685	49,440	47,382	95.8	4.2	.....	.....	3.5	.....	.7
14	64,988	49,440	46,364	93.8	6.2	.....	.....	3.3	.....	2.9
21	64,526	49,440	43,005	87.0	13.0	.....	.....	5.9	.....	7.1
28	64,179	49,440	44,359	89.7	10.3	.....	.....	4.7	.....	5.6
Total 52 weeks	3,195,928	2,564,789	2,256,726	88.0	12.0	7.8	.2	2.7	.....	1.3

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By-product coke produced in the United States and in several States, 1918, by weeks—Continued.

Indiana.

Week ended—	Coal charged (net tons).	Maximum weekly capacity (net tons).	Coke produced.		Percentage of coke "lost" on account of—					
			Quantity (net tons).	Percentage of capacity.	Total.	No coal.	Labor trouble.	Plant disability.	No demand.	Other causes.
Jan. 5	79,486	77,674	58,334	75.1	24.9	24.4	.....	0.5	.....	.....
12	54,982	77,674	39,239	50.5	49.5	43.7	.....	.3	.....	5.5
19	38,410	77,674	27,452	35.3	64.7	55.5	.....	.9	.....	8.3
26	52,082	91,674	38,564	42.1	57.9	53.6	.....	.4	.....	3.9
Feb. 2	54,593	91,792	38,831	42.3	57.7	54.0	.....	.2	.....	3.5
9	62,875	91,792	44,312	48.3	51.7	50.8	.....	.9	.....	.....
16	70,686	91,792	49,456	53.9	46.1	45.1	.....	.8	.....	.2
23	73,264	91,792	51,324	55.9	44.1	42.9	.....	1.0	.....	.2
Mar. 2	78,599	91,792	56,663	61.7	38.3	35.0	.....	3.1	.....	.2
9	97,732	91,792	71,182	77.5	22.5	19.8	.....	2.6	.....	.1
16	98,415	91,792	73,977	80.6	19.4	17.5	.....	1.8	.....	.1
23	99,020	92,292	72,859	78.9	21.1	19.3	.....	1.7	.....	.1
30	96,709	91,792	72,615	79.1	20.9	18.5	.....	2.3	.....	.1
Apr. 6	97,787	91,792	71,700	78.1	21.9	19.1	.....	2.7	.....	.1
13	98,914	91,792	73,464	80.0	20.0	17.6	.....	2.3	.....	.1
20	98,064	91,792	70,849	77.2	22.8	20.2	.....	2.5	.....	.1
27	98,436	91,822	72,723	79.2	20.8	18.4	.....	2.3	.....	.1
May 4	105,814	91,797	78,551	85.6	14.4	12.5	.....	.4	.....	1.5
11	108,470	92,134	80,158	87.0	13.0	11.5	.....	1.4	.....	.1
18	108,026	91,791	79,616	86.7	13.3	11.7	.....	1.5	.....	.1
25	108,192	91,792	79,539	86.7	13.3	11.9	.....	1.2	.....	.2
June 1	107,995	91,929	80,230	87.3	12.7	11.6	.....	.9	.....	.2
8	108,469	92,327	81,197	87.9	12.1	10.4	.....	1.5	.....	.2
15	106,678	92,221	80,451	87.2	12.8	11.5	.....	1.1	.....	.2
22	114,694	90,129	84,361	93.6	6.4	3.9	.....	2.3	.....	.2
29	115,232	90,129	85,319	94.7	5.3	3.0	.....	2.1	.....	.2
July 6	115,203	90,129	85,673	95.1	4.9	2.8	0.5	1.4	.....	.2
13	119,346	90,187	86,193	95.6	4.4	3.2	1.0	.....	.....	.2
20	118,229	90,543	86,231	95.2	4.8	3.6	1.1	.....	.....	.1
27	117,256	90,472	85,651	94.7	5.3	3.4	.....	.....	.....	1.9
Aug. 3	116,609	90,223	85,084	94.3	5.7	4.2	1.3	.....	.....	.2
10	112,626	89,805	80,126	89.2	10.8	9.6	1.0	.1	.....	.1
17	106,177	89,694	74,116	82.6	17.4	15.6	1.5	.2	.....	.1
24	106,510	89,694	74,606	83.2	16.8	15.2	1.0	.5	.....	.1
31	106,472	89,699	75,347	84.0	16.0	15.4	.4	.....	.....	.2
Sept. 7	106,482	89,886	75,790	84.3	15.7	14.2	1.4	.....	.....	.1
14	106,872	89,930	75,226	83.6	16.4	14.3	1.0	1.0	.....	.1
21	109,597	89,823	77,076	85.8	14.2	12.1	1.0	1.0	.....	.1
28	115,801	89,694	82,410	91.9	8.1	6.0	.9	1.0	.....	.2
Oct. 5	116,041	89,771	81,955	91.3	8.7	6.6	1.0	1.0	.....	.1
12	115,621	89,694	82,246	91.7	8.3	5.5	1.1	1.6	.....	.1
19	114,349	89,694	81,135	90.5	9.5	6.2	1.0	1.3	.....	1.0
26	114,676	89,694	81,146	90.5	9.5	6.5	.9	2.1	.....	.....
Nov. 2	117,498	89,708	82,100	91.5	8.5	6.9	.....	.5	.....	1.1
9	117,961	90,179	83,200	92.3	7.7	5.9	.7	1.0	.....	.1
16	117,287	90,233	84,892	94.1	5.9	2.0	2.8	1.0	.....	.1
23	116,677	89,954	86,805	96.5	3.5	.....	.8	2.6	.....	.1
30	116,076	90,230	82,886	91.9	8.1	.....	1.0	7.0	.....	.1
Dec. 7	118,112	90,357	86,308	95.5	4.5	.....	.2	4.2	.....	.1
14	117,289	90,406	83,124	91.9	8.1	.....	.8	1.2	.....	6.1
21	117,378	90,744	83,945	92.5	7.5	.....	1.5	.6	.....	5.4
28	115,327	90,726	83,191	91.7	8.3	.....	1.1	1.6	.....	5.6
Total 52 weeks	5,305,096	4,683,940	3,839,428	82.0	18.0	15.3	.5	1.3	.....	.9

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By-product coke produced in the United States and in several States, 1918, by weeks—Continued.

Kentucky.

Week ended—	Coal charged (net tons).	Maximum weekly capacity (net tons).	Coke produced.		Percentage of coke "lost" on account of—					
			Quantity (net tons).	Percentage of capacity.	Total.	No coal.	Labor trouble.	Plant disability.	No demand.	Other causes.
Jan. 5	13,843	10,647	9,974	93.7	6.3	.....	.....	.....	.....	6.3
12	13,871	10,647	10,519	98.8	1.2	.....	.....	.....	.....	1.2
19	12,165	10,647	8,950	84.1	15.9	.....	.....	.....	.....	15.9
26	13,643	10,647	10,301	96.8	3.2	.....	.....	.....	.....	3.2
Feb. 2	13,615	10,647	10,198	95.8	4.2	.....	.....	.....	.....	4.2
9	13,989	10,647	10,405	97.7	2.3	.....	.....	.....	.....	2.3
16	14,233	11,027	11,027	100.0	.....	.....	.....	.....	.....	.....
23	14,020	11,027	10,354	93.9	6.1	.....	.....	.....	.....	6.1
Mar. 2	14,202	11,046	11,046	100.0	.....	.....	.....	.....	.....	.....
9	14,205	11,046	10,677	96.7	3.3	.....	.....	3.3	.....	.....
16	14,183	11,046	10,367	93.9	6.1	.....	.....	6.1	.....	.....
23	14,275	11,122	11,122	100.0	.....	.....	.....	.....	.....	.....
30	14,119	11,122	10,482	94.2	5.8	.....	.....	5.8	.....	.....
Apr. 6	13,951	11,122	10,122	91.0	9.0	.....	.....	9.0	.....	.....
13	14,170	11,122	10,360	93.1	6.9	.....	.....	6.9	.....	.....
20	14,054	11,122	10,248	92.1	7.9	.....	.....	7.9	.....	.....
27	14,051	11,122	10,040	90.3	9.7	.....	.....	9.7	.....	.....
May 4	13,760	11,122	9,540	85.8	14.2	.....	.....	14.2	.....	.....
11	13,865	11,122	9,969	89.6	10.4	.....	.....	10.4	.....	.....
18	14,021	11,122	9,969	89.6	10.4	.....	.....	10.4	.....	.....
25	14,043	11,122	9,662	86.9	13.1	.....	.....	13.1	.....	.....
June 1	13,851	11,122	10,107	90.9	9.1	.....	.....	9.1	.....	.....
8	13,852	11,122	9,860	88.7	11.3	.....	.....	11.3	.....	.....
15	14,013	11,122	9,778	87.9	12.1	.....	.....	12.1	.....	.....
22	13,872	11,122	10,675	96.0	4.0	.....	.....	4.0	.....	.....
29	13,912	11,122	10,093	90.7	9.3	.....	.....	9.3	.....	.....
July 6	13,828	11,122	9,793	88.1	11.9	.....	.....	11.9	.....	.....
13	13,994	11,122	9,878	88.8	11.2	.....	.....	11.2	.....	.....
20	13,994	11,122	10,106	90.9	9.1	.....	.....	9.1	.....	.....
27	13,743	11,122	9,701	87.2	12.8	.....	.....	12.8	.....	.....
Aug. 3	14,061	11,122	10,093	90.7	9.3	.....	.....	9.3	.....	.....
10	13,448	11,122	9,509	85.5	14.5	.....	.....	14.5	.....	.....
17	13,540	11,122	9,837	88.4	11.6	.....	.....	11.6	.....	.....
24	13,935	11,122	9,731	87.5	12.5	.....	.....	12.5	.....	.....
31	13,776	11,122	9,640	86.7	13.3	.....	.....	13.3	.....	.....
Sept. 7	13,741	11,122	9,870	88.7	11.3	.....	.....	11.3	.....	.....
14	12,761	11,122	9,234	83.0	17.0	.....	.....	17.0	.....	.....
21	13,222	11,122	9,267	83.3	16.7	.....	.....	16.7	.....	.....
28	13,422	11,122	9,153	82.3	17.7	.....	.....	17.7	.....	.....
Oct. 5	15,226	11,122	9,597	86.3	13.7	.....	.....	13.7	.....	.....
12	14,040	11,122	9,598	86.3	13.7	.....	.....	13.7	.....	.....
19	13,852	11,122	9,373	84.3	15.7	.....	.....	15.7	.....	.....
26	13,868	11,122	9,603	86.3	13.7	.....	.....	13.7	.....	.....
Nov. 2	14,083	11,122	9,514	85.5	14.5	.....	.....	14.5	.....	.....
9	13,973	11,122	9,864	88.7	11.3	.....	.....	11.3	.....	.....
16	14,042	11,122	9,654	86.8	13.2	.....	.....	13.2	.....	.....
23	13,294	11,122	9,408	84.6	15.4	.....	.....	15.4	.....	.....
30	14,022	11,122	10,288	92.5	7.5	.....	.....	7.5	.....	.....
Dec. 7	13,804	11,122	9,679	87.0	13.0	.....	.....	13.0	.....	.....
14	13,483	11,122	9,547	85.8	14.2	.....	.....	14.2	.....	.....
21	13,812	11,122	9,549	85.9	14.1	.....	.....	14.1	.....	.....
28	13,999	11,122	9,626	86.5	13.5	.....	.....	13.5	.....	.....
Total 52 weeks	720,741	575,076	516,957	89.9	10.1	.....	.....	9.4	.....	.7

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By-product coke produced in the United States and in several States, 1918, by weeks—Continued.

Maryland.

Week ended—	Coal charged (net tons).	Maximum weekly capacity (net tons).	Coke produced.		Percentage of coke "lost" on account of—					
			Quantity (net tons).	Percentage of capacity.	Total.	No coal.	Labor trouble.	Plant disability.	No demand.	Other causes.
Jan. 5	8,649	9,500	5,551	58.4	41.6	40.9	.....	.....	.....	0.7
12	8,217	9,500	5,288	55.7	44.3	43.8	.....	0.5	.....	.....
19	9,428	9,500	5,896	62.1	37.9	35.1	.....	2.8	.....	.....
26	11,488	9,500	6,932	73.0	27.0	27.0	.....	.....	.....	.....
Feb. 2	12,750	9,500	8,011	84.3	15.7	12.3	.....	3.4	.....	.....
9	8,697	9,500	5,421	57.1	42.9	39.5	.....	3.4	.....	.....
16	8,206	9,500	5,260	55.4	44.6	42.0	.....	2.6	.....	.....
23	12,990	9,500	8,625	90.8	9.2	5.9	.....	3.3	.....	.....
Mar. 2	14,095	9,900	9,685	97.8	2.2	.....	.....	2.2	.....	.....
9	14,445	10,250	10,015	97.7	2.3	.....	.....	2.3	.....	.....
16	14,485	10,250	10,172	99.2	.8	.....	.....	.....	.....	.8
23	14,989	10,334	10,334	100.0	.....	.....	.....	.....	.....	.....
30	14,896	10,549	10,549	100.0	.....	.....	.....	.....	.....	.....
Apr. 6	14,917	10,451	10,451	100.0	.....	.....	.....	.....	.....	.....
13	14,476	10,255	10,133	98.8	1.2	.....	.....	.....	.....	1.2
20	14,803	10,412	10,412	100.0	.....	.....	.....	.....	.....	.....
27	14,766	10,255	10,189	99.4	.6	.....	.....	.....	.....	.6
May 4	14,961	10,255	9,802	95.6	4.4	.....	.....	.....	.....	4.4
11	15,006	10,255	10,156	99.0	1.0	.....	.....	.....	.....	1.0
18	14,822	10,357	10,357	100.0	.....	.....	.....	.....	.....	.....
25	12,460	10,255	8,844	86.2	13.8	.....	13.8	.....	.....	.....
June 1	14,338	10,255	10,117	98.7	1.3	.....	1.3	.....	.....	.....
8	14,958	10,595	10,595	100.0	.....	.....	.....	.....	.....	.....
15	14,855	10,530	10,530	100.0	.....	.....	.....	.....	.....	.....
22	14,660	10,255	10,176	99.2	.8	.....	.....	.....	.....	.8
29	14,494	10,255	10,162	99.1	.9	.....	.....	.....	.....	.9
July 6	14,338	10,255	10,084	98.3	1.7	.....	.....	.....	.....	1.7
13	14,623	10,255	10,133	98.8	1.2	.....	.....	1.2	.....	.....
20	14,300	10,255	9,836	95.9	4.1	.....	.....	.....	.....	4.1
27	14,308	10,255	9,944	97.0	3.0	.....	.....	3.0	.....	.....
Aug. 3	14,691	10,255	10,082	98.3	1.7	.....	.....	1.7	.....	.....
10	10,642	10,255	7,468	72.8	27.2	.....	.....	.....	.....	27.2
17	11,744	10,255	8,273	80.7	19.3	.....	19.3	.....	.....	.....
24	12,902	10,355	9,433	92.0	8.0	.....	8.0	.....	.....	.....
31	11,868	10,255	8,284	80.8	19.2	.....	19.2	.....	.....	.....
Sept. 7	12,709	10,255	8,813	85.9	14.1	.....	14.1	.....	.....	.....
14	13,726	10,255	9,711	94.7	5.3	.....	5.3	.....	.....	.....
21	13,418	10,255	9,383	91.5	8.5	.....	.....	.....	.....	8.5
28	14,072	10,255	9,857	96.1	3.9	.....	.....	.....	.....	3.9
Oct. 5	13,829	10,255	9,524	92.9	7.1	.....	7.1	.....	.....	.....
12	13,166	10,255	9,148	89.2	10.8	.....	10.8	.....	.....	.....
19	13,457	10,255	9,412	91.8	8.2	.....	8.2	.....	.....	.....
26	13,821	10,255	9,548	93.1	6.9	.....	6.9	.....	.....	.....
Nov. 2	12,318	10,255	8,380	81.7	18.3	.....	18.3	.....	.....	.....
9	13,314	10,255	9,048	88.2	11.8	.....	11.8	.....	.....	.....
16	15,026	10,255	8,781	85.6	14.4	.....	7.2	7.2	.....	.....
23	15,002	10,255	8,755	85.4	14.6	.....	7.3	7.3	.....	.....
30	14,337	10,255	9,180	89.5	10.5	.....	4.9	5.6	.....	.....
Dec. 7	13,805	10,255	9,049	88.2	11.8	.....	5.9	5.9	.....	.....
14	14,014	10,255	9,436	92.0	8.0	.....	.....	8.0	.....	.....
21	13,970	10,255	9,560	93.2	6.8	.....	.....	.....	.....	6.8
28	14,468	11,255	9,283	82.5	17.5	.....	.....	.....	.....	17.5
Total 52 weeks	696,719	529,298	474,068	89.6	10.4	4.4	3.3	1.1	.....	1.6

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By-product coke produced in the United States and in several States, 1918, by weeks—Continued.

Massachusetts.

Week ended—	Coal charged (net tons).	Maximum weekly capacity (net tons).	Coke produced.		Percentage of coke "lost" on account of—					
			Quantity (net tons).	Percentage of capacity.	Total.	No coal.	Labor trouble.	Plant disability.	No demand.	Other causes.
Jan. 5	13,453	11,760	10,762	91.5	8.5	8.5	.....	.....	.....	.....
12	11,308	11,760	9,046	76.9	23.1	23.1	.....	.....	.....	.....
19	11,211	11,760	8,969	76.3	23.7	23.7	.....	.....	.....	.....
26	11,269	11,760	9,015	76.7	23.3	23.3	.....	.....	.....	.....
Feb. 2	11,269	11,760	9,015	76.7	23.3	23.3	.....	.....	.....	.....
9	11,334	11,760	9,067	77.1	22.9	22.9	.....	.....	.....	.....
16	11,246	11,760	9,408	80.0	20.0	20.0	.....	.....	.....	.....
23	11,239	11,760	8,991	76.5	23.5	23.5	.....	.....	.....	.....
Mar. 2	11,594	11,760	9,275	78.9	21.1	21.1	.....	.....	.....	.....
9	13,562	11,760	10,850	92.3	7.7	7.7	.....	.....	.....	.....
16	13,663	11,760	10,930	92.9	7.1	7.1	.....	.....	.....	.....
23	13,773	11,760	11,018	93.7	6.3	6.3	.....	.....	.....	.....
30	14,408	11,760	11,526	98.0	2.0	2.0	.....	.....	.....	.....
Apr. 6	14,176	11,760	11,341	96.4	3.6	.....	.....	.....	.....	3.6
13	14,223	11,760	11,378	96.8	3.2	.....	.....	.....	3.2	.....
20	14,072	11,760	11,258	95.7	4.3	.....	.....	4.3	.....	.....
27	14,003	11,760	11,202	95.3	4.7	.....	.....	4.7	.....	.....
May 4	13,828	11,760	11,062	94.1	5.9	.....	.....	5.9	.....	.....
11	13,763	11,760	11,010	93.6	6.4	.....	.....	6.4	.....	.....
18	13,698	11,760	11,174	95.0	5.0	.....	.....	5.0	.....	.....
25	14,124	11,760	11,299	96.1	3.9	.....	.....	3.9	.....	.....
June 1	14,213	11,760	11,370	96.7	3.3	.....	.....	3.3	.....	.....
8	14,019	11,760	11,215	95.4	4.6	.....	.....	4.6	.....	.....
15	13,563	11,760	10,850	92.3	7.7	.....	.....	7.7	.....	.....
22	13,619	11,760	10,895	92.6	7.4	.....	.....	7.4	.....	.....
29	13,569	11,760	10,855	92.3	7.7	.....	.....	7.7	.....	.....
July 6	13,859	11,760	11,087	94.3	5.7	.....	.....	5.7	.....	.....
13	13,736	11,760	10,989	93.4	6.6	.....	.....	6.6	.....	.....
20	14,432	11,760	11,546	98.2	1.8	.....	.....	1.8	.....	.....
27	14,702	11,762	11,762	100.0	.....	.....	.....	.....	.....	.....
Aug. 3	14,600	11,760	11,680	99.3	.7	.....	.....	.7	.....	.....
10	14,242	11,760	11,394	96.9	3.1	.....	.....	3.1	.....	.....
17	14,152	11,760	11,322	96.3	3.7	.....	.....	3.7	.....	.....
24	13,989	11,760	11,191	95.2	4.8	.....	.....	4.8	.....	.....
31	14,057	11,760	11,246	95.6	4.4	.....	.....	4.4	.....	.....
Sept. 7	14,087	11,760	11,270	95.8	4.2	.....	.....	4.2	.....	.....
14	14,100	11,760	11,280	95.9	4.1	.....	.....	4.1	.....	.....
21	14,050	11,760	11,240	95.6	4.4	.....	.....	4.4	.....	.....
28	14,111	11,760	11,289	96.0	4.0	.....	.....	4.0	.....	.....
Oct. 5	14,090	11,760	11,272	95.9	4.1	.....	.....	4.1	.....	.....
12	14,076	11,760	11,261	95.8	4.2	.....	.....	4.2	.....	.....
19	14,160	11,760	11,328	96.3	3.7	.....	.....	3.7	.....	.....
26	14,444	11,760	11,555	98.3	1.7	.....	1.7	.....	.....	.....
Nov. 2	14,240	11,760	11,392	96.9	3.1	.....	3.1	.....	.....	.....
9	13,261	11,760	10,608	90.2	9.8	.....	.....	9.8	.....	.....
16	9,901	11,760	7,921	67.4	32.6	.....	.....	32.6	.....	.....
23	8,975	11,760	7,180	61.1	38.9	.....	.....	.....	38.9	.....
30	9,219	11,760	7,375	62.7	37.3	.....	.....	.....	37.3	.....
Dec. 7	9,197	11,760	7,358	62.6	37.4	.....	.....	.....	37.4	.....
14	9,229	11,760	7,383	62.8	37.2	.....	.....	.....	37.2	.....
21	9,227	11,760	7,382	62.8	37.2	.....	.....	.....	37.2	.....
28	9,209	11,760	7,367	62.6	37.4	.....	.....	.....	37.4	.....
Total 52 weeks	673,544	611,522	539,459	88.2	11.8	4.1	.1	3.1	4.4	.1

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By-product coke produced in the United States and in several States, 1918, by weeks—Continued.

Minnesota.

Week ended—	Coal charged (net tons).	Maximum weekly capacity (net tons).	Coke produced.		Percentage of coke "lost" on account of—					
			Quantity (net tons).	Percentage of capacity.	Total.	No coal.	Labor trouble.	Plant disability.	No demand.	Other causes.
Jan. 5	13,351	10,306	9,584	93.0	7.0	.....	.....	6.4	.....	0.6
12	14,243	10,450	10,410	99.6	.4	.....	.....	.....	.....	.4
19	14,077	10,450	10,203	97.6	2.4	.....	.....	.....	.....	2.4
26	13,393	10,450	9,514	91.0	9.0	.....	.....	.....	.....	9.0
Feb. 2	13,521	10,450	9,936	95.1	4.9	.....	.....	.....	.....	4.9
9	13,507	10,438	9,916	95.0	5.0	.....	.....	.....	.....	5.0
16	13,643	10,438	9,595	91.9	8.1	.....	.....	.....	.....	8.1
23	13,540	10,438	9,730	93.2	6.8	.....	.....	.....	.....	6.8
Mar. 2	13,580	10,438	9,758	93.5	6.5	.....	.....	.....	.....	6.5
9	20,695	15,695	15,188	96.8	3.2	.....	.....	.....	.....	3.2
16	20,720	15,900	15,269	96.0	4.0	.....	.....	.....	.....	4.0
23	20,748	16,118	15,442	95.8	4.2	.....	.....	.....	.....	4.2
30	20,181	16,026	14,794	92.3	7.7	.....	.....	.....	7.7	.....
Apr. 6	19,497	15,343	13,871	90.4	9.6	.....	.....	.....	9.3	.3
13	19,454	15,542	13,999	90.1	9.9	.....	.....	.....	9.1	.8
20	19,456	15,259	13,615	89.2	10.8	.....	.....	.....	10.1	.7
27	19,939	15,980	14,395	90.1	9.9	.....	.....	.....	9.3	.6
May 4	20,216	16,027	14,538	90.7	9.3	.....	.....	.....	9.3	.....
11	20,213	16,411	14,744	89.8	10.2	.....	.....	.....	9.4	.8
18	19,607	16,308	14,605	89.6	10.4	.....	.....	.2	9.6	.6
25	19,617	17,171	14,746	85.9	14.1	.....	.....	.....	7.6	6.5
June 1	20,149	17,106	14,262	83.4	16.6	.....	.....	.....	9.3	7.3
8	20,508	15,994	15,044	94.1	5.9	.....	.....	.....	5.4	.5
15	21,231	16,435	15,452	94.0	6.0	.....	.....	.....	4.5	1.5
22	21,310	16,770	16,223	96.7	3.3	.....	.....	.....	1.7	1.6
29	21,292	16,827	16,012	95.2	4.8	.....	.....	.....	1.5	3.3
July 6	20,915	16,748	15,471	92.4	7.6	.....	.....	.....	4.1	3.5
13	20,774	16,810	15,266	90.8	9.2	.....	.....	.....	3.7	5.5
20	20,722	16,724	15,144	90.6	9.4	.....	.....	.....	3.6	5.8
27	20,841	16,740	15,338	91.6	8.4	.....	.....	.....	2.6	5.8
Aug. 3	21,090	16,271	15,388	94.6	5.4	.....	.....	.....	.....	5.4
10	21,033	16,335	15,410	94.3	5.7	.....	.....	.....	.....	5.7
17	20,920	16,400	15,748	96.0	4.0	.....	.....	.....	.....	4.0
24	20,935	16,390	15,473	94.4	5.6	.....	.....	.....	.....	5.6
31	21,019	16,324	15,502	95.0	5.0	.....	.....	.....	.....	5.0
Sept. 7	21,188	16,350	15,553	95.1	4.9	.....	.....	.....	.....	4.9
14	21,024	16,317	15,361	94.1	5.9	.....	.....	.....	.....	5.9
21	20,893	16,370	15,167	92.7	7.3	.....	.....	.....	.....	7.3
28	20,989	16,340	15,246	93.3	6.7	.....	.....	.....	.....	6.7
Oct. 5	20,566	17,020	14,098	82.8	17.2	.....	.....	.....	.....	17.2
12	20,248	16,402	15,470	94.3	5.7	.....	.....	.....	.....	5.7
19	19,393	15,315	14,065	91.8	8.2	.....	.....	.....	.....	8.2
26	21,025	16,859	15,789	93.7	6.3	.....	.....	.....	.....	6.3
Nov. 2	21,329	17,339	15,200	87.7	12.3	.....	.....	.....	.....	12.3
9	21,419	17,339	15,169	87.5	12.5	.....	.....	.....	.....	12.5
16	21,798	16,494	15,351	93.1	6.9	.....	.....	.....	.....	6.9
23	21,592	17,339	15,617	90.1	9.9	.....	.....	.....	.....	9.9
30	21,785	17,339	15,339	88.5	11.5	.....	.....	.....	.....	11.5
Dec. 7	21,308	17,339	14,514	83.7	16.3	.....	.....	.....	.....	16.3
14	21,444	17,339	14,727	84.9	15.1	.....	.....	.....	.....	15.1
21	21,204	17,339	15,204	87.7	12.3	.....	.....	.....	.....	12.3
28	21,396	17,339	14,971	86.3	13.7	.....	.....	.....	.....	13.7
Total 52 weeks	1,014,538	803,691	736,426	91.6	8.4	.....	.....	.1	2.4	5.9

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By-product coke produced in the United States and in several States, 1918, by weeks—Continued.

New Jersey.

Week ended—	Coal charged (net tons).	Maximum weekly capacity (net tons).	Coke produced.		Percentage of coke "lost" on account of—					
			Quantity (net tons).	Percentage of capacity.	Total.	No coal.	Labor trouble.	Plant disability.	No demand.	Other causes.
Jan. 5	13,819	15,565	10,095	64.8	35.2	35.2	.....	.....	.....	.....
12	13,912	16,009	9,576	59.8	40.2	38.5	.....	1.7	.....	.....
19	13,486	16,009	8,836	55.2	44.8	43.1	.....	1.7	.....	.....
26	14,891	16,009	9,042	56.5	43.5	38.3	.....	5.2	.....	.....
Feb. 2	15,726	16,009	10,585	66.1	33.9	28.7	.....	4.1	.....	1.1
9	16,428	16,009	11,233	70.2	29.8	27.4	.....	2.4	.....	.....
16	15,190	16,009	9,794	61.2	38.8	37.0	.....	1.8	.....	.....
23	16,650	16,009	12,134	75.8	24.2	22.0	.....	2.2	.....	.....
Mar. 2	17,422	16,009	11,533	72.0	28.0	26.4	.....	1.6	.....	.....
9	17,457	16,009	12,185	76.1	23.9	21.2	.....	2.7	.....	.....
16	17,498	16,009	12,242	76.5	23.5	21.8	.....	1.7	.....	.....
23	17,686	16,009	12,744	79.6	20.4	19.2	.....	1.2	.....	.....
30	18,355	16,009	12,862	80.3	19.7	18.0	.....	1.7	.....	.....
Apr. 6	18,451	16,009	12,864	80.4	19.6	18.0	.....	1.6	.....	.....
13	18,790	16,009	12,965	81.0	19.0	19.0	.....	.....	.....	.....
20	19,368	16,009	13,555	84.7	15.3	15.3	.....	.....	.....	.....
27	20,373	16,009	14,215	88.8	11.2	11.2	.....	.....	.....	.....
May 4	20,864	16,009	14,451	90.3	9.7	9.7	.....	.....	.....	.....
11	20,268	16,009	14,148	88.4	11.6	10.1	.....	1.5	.....	.....
18	19,942	16,009	14,272	89.1	10.9	8.9	.....	2.0	.....	.....
25	20,154	16,009	14,187	88.6	11.4	7.1	.....	4.3	.....	.....
June 1	19,949	16,009	13,904	86.9	13.1	8.3	.....	4.8	.....	.....
8	19,500	16,009	13,561	84.7	15.3	9.9	.....	5.4	.....	.....
15	20,262	16,009	14,205	88.7	11.3	6.9	.....	4.4	.....	.....
22	19,842	16,009	13,942	87.1	12.9	8.1	.....	4.8	.....	.....
29	20,210	16,009	14,248	89.0	11.0	7.4	.....	3.6	.....	.....
July 6	20,446	16,009	14,062	91.6	8.4	6.6	.....	1.8	.....	.....
13	20,393	16,009	14,629	91.4	8.6	6.6	.....	2.0	.....	.....
20	20,271	16,009	14,564	91.0	9.0	6.6	.....	2.4	.....	.....
27	20,337	16,009	14,585	91.1	8.9	7.2	.....	1.7	.....	.....
Aug. 3	20,096	16,009	14,470	90.4	9.6	6.6	.....	3.0	.....	.....
10	19,966	16,009	14,252	89.0	11.0	7.3	.....	3.1	.....	.6
17	19,853	16,009	14,287	89.2	10.8	7.3	.....	1.6	.....	1.9
24	20,100	16,009	14,455	90.3	9.7	7.0	.....	2.7	.....	.....
31	20,157	16,009	14,293	89.3	10.7	7.2	.....	3.5	.....	.....
Sept. 7	20,163	16,009	14,511	90.6	9.4	6.7	.....	2.7	.....	.....
14	20,068	16,009	14,417	90.1	9.9	6.9	.....	3.0	.....	.....
21	20,014	16,009	14,375	89.8	10.2	8.1	.....	2.1	.....	.....
28	20,114	16,009	14,474	90.4	9.6	7.4	.....	2.2	.....	.....
Oct. 5	20,118	16,009	14,195	88.7	11.3	8.8	.....	2.5	.....	.....
12	20,260	16,009	14,563	91.0	9.0	7.0	.....	2.0	.....	.....
19	20,381	16,009	13,873	86.7	13.3	11.3	.....	1.5	.....	.5
26	20,319	16,009	14,768	92.2	7.8	.....	5.6	2.2	.....	.....
Nov. 2	20,216	16,009	15,207	95.0	5.0	.....	2.3	2.7	.....	.....
9	20,216	16,009	14,048	87.8	12.2	.....	10.0	2.2	.....	.....
16	18,484	16,009	13,882	86.7	13.3	.....	.1	1.8	.....	11.4
23	20,635	16,000	15,172	94.8	5.2	.....	.....	.1	.....	5.1
30	18,746	16,009	14,758	92.2	7.8	.....	6.2	.....	.....	1.6
Dec. 7	20,671	16,009	14,565	91.0	9.0	.....	6.2	.....	.....	2.8
14	20,645	16,009	14,459	90.3	9.7	.....	.....	.....	.....	9.7
21	20,745	16,009	14,896	93.0	7.0	.....	.....	.....	.....	7.0
28	20,610	16,009	14,840	92.7	7.3	.....	.....	.1	.....	7.2
Total 52 weeks	990,517	832,015	700,578	84.2	15.8	12.2	.6	2.1	.....	.9

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By-product coke produced in the United States and in several States, 1918, by weeks—Continued.

New York.

Week ended—	Coal charged (net tons).	Maximum weekly capacity (net tons).	Coke produced.		Percentage of coke "lost" on account of—					
			Quantity (net tons).	Percentage of capacity.	Total.	No coal.	Labor trouble.	Plant disability.	No demand.	Other causes.
Jan. 5	21,261	24,053	15,547	64.6	35.4	31.9	.....	.....	.....	3.5
12	22,183	24,053	15,618	64.9	35.1	32.0	.....	.....	.....	3.1
19	20,306	24,053	13,715	57.0	43.0	29.2	.....	.....	.....	13.8
26	24,958	24,053	17,042	70.8	29.2	22.8	.....	.....	.....	6.4
Feb. 2	24,574	24,053	17,165	69.0	31.0	21.1	.....	.....	.....	9.9
9	22,216	24,053	16,071	66.8	33.2	29.9	.....	.....	.....	3.3
16	22,579	24,053	15,888	66.1	33.9	31.8	.....	.....	.....	2.1
23	25,943	24,053	18,100	75.3	24.7	20.5	.....	.....	.....	4.2
Mar. 2	28,651	23,927	20,270	84.7	15.3	14.3	.....	.....	.....	1.0
9	30,669	23,927	21,277	88.9	11.1	9.2	.....	1.9	.....	.....
16	30,965	24,063	21,967	91.3	8.7	.....	.....	.6	.....	8.1
23	31,461	24,063	21,856	90.8	9.2	.....	.....	9.2	.....	.....
30	31,671	24,718	22,741	92.0	8.0	.....	.....	8.0	.....	.....
Apr. 6	31,746	24,718	22,444	90.8	9.2	.....	.....	9.2	.....	.....
13	31,068	24,718	22,643	91.6	8.4	.....	.....	8.4	.....	.....
20	31,023	24,718	22,375	90.5	9.5	.....	.....	9.5	.....	.....
27	31,014	24,718	21,819	88.3	11.7	.....	.....	11.7	.....	.....
May 4	31,235	24,718	22,290	90.2	9.8	.....	.....	9.8	.....	.....
11	31,689	24,718	21,826	88.3	11.7	.....	.....	11.7	.....	.....
18	31,450	24,802	23,246	93.7	6.3	.....	.....	6.3	.....	.....
25	31,338	24,802	22,022	88.8	11.2	.....	.....	11.2	.....	.....
June 1	31,558	24,802	22,095	89.1	10.9	.....	.....	10.9	.....	.....
8	32,067	24,802	22,469	90.6	9.4	.....	.....	9.4	.....	.....
15	32,167	24,802	23,038	92.9	7.1	.....	.....	7.1	.....	.....
22	32,095	24,802	21,990	88.7	11.3	.....	.....	11.3	.....	.....
29	32,122	24,802	22,098	89.1	10.9	.....	.....	10.9	.....	.....
July 6	31,564	24,802	22,175	89.4	10.6	.....	.....	10.6	.....	.....
13	31,890	24,802	22,621	91.2	8.8	.....	.....	8.8	.....	.....
20	30,421	24,802	21,507	86.7	13.3	.....	7.6	5.7	.....	.....
27	30,451	24,802	21,117	85.1	14.9	.....	7.2	7.7	.....	.....
Aug. 3	30,201	24,802	21,580	87.0	13.0	.....	5.7	7.3	.....	.....
10	30,113	24,802	21,293	85.9	14.1	.....	6.1	8.0	.....	.....
17	28,835	24,802	20,761	83.7	16.3	.....	2.6	13.7	.....	.....
24	28,983	24,802	20,606	83.1	16.9	.....	3.3	13.6	.....	.....
31	29,188	24,802	20,601	83.1	16.9	.....	2.9	14.0	.....	.....
Sept. 7	29,479	24,802	20,971	84.6	15.4	.....	3.5	11.9	.....	.....
14	29,377	24,802	20,697	83.4	16.6	.....	4.0	12.6	.....	.....
21	30,404	24,802	20,895	84.2	15.8	.....	4.2	11.6	.....	.....
28	30,459	24,802	22,180	89.4	10.6	.....	.....	10.6	.....	.....
Oct. 5	29,876	24,802	21,183	85.4	14.6	.....	3.8	10.8	.....	.....
12	30,214	24,802	21,279	85.8	14.2	.....	3.5	10.7	.....	.....
19	30,407	24,802	21,156	85.3	14.7	.....	4.1	10.6	.....	.....
26	29,136	24,802	20,619	83.1	16.9	.....	5.0	11.9	.....	.....
Nov. 2	29,567	24,802	20,573	82.9	17.1	.....	4.6	12.5	.....	.....
9	28,643	24,802	19,741	79.6	20.4	.....	6.7	13.7	.....	.....
16	30,232	24,802	21,125	85.2	14.8	.....	3.7	11.1	.....	.....
23	28,705	24,893	19,074	76.6	23.4	.....	8.2	15.2	.....	.....
30	27,944	24,893	19,589	78.7	21.3	.....	4.0	17.3	.....	.....
Dec. 7	22,644	24,893	17,586	70.6	29.4	13.9	3.7	11.8	.....	.....
14	26,748	24,893	18,775	75.4	24.6	9.8	3.5	11.3	.....	.....
21	28,228	24,893	19,646	78.9	21.1	6.8	3.1	11.2	.....	.....
28	30,675	24,893	20,938	84.1	15.9	.....	4.0	11.9	.....	.....
Total 52 weeks	1,512,613	1,280,442	1,065,900	83.2	16.8	5.1	2.0	8.7	.....	1.0

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By-product coke produced in the United States and in several States, 1918, by weeks—Continued.

Ohio.

Week ended—	Coal charged (net tons).	Maximum weekly capacity (net tons).	Coke produced.		Percentage of coke "lost" on account of—					
			Quantity (net tons).	Percentage of capacity.	Total.	No coal.	Labor trouble.	Plant disability.	No demand.	Other causes.
Jan. 5	104,627	85,326	73,026	85.6	14.4	11.6	.....	2.6	.....	0.2
12	102,616	86,867	70,880	81.6	18.4	15.6	.....	2.5	.....	.3
19	91,514	86,940	63,896	73.5	26.5	18.0	0.6	6.2	.....	1.7
26	92,532	87,340	64,874	74.3	25.7	22.0	.6	2.5	.....	.6
Feb. 2	91,279	87,349	62,458	71.5	28.5	24.1	.....	2.7	.....	1.7
9	93,662	87,561	65,049	74.3	25.7	23.3	.....	2.0	.....	.4
16	98,394	88,027	68,223	77.5	22.5	16.7	.....	1.6	.....	4.2
23	103,325	85,661	70,366	82.1	17.9	8.6	.6	2.3	.....	6.4
Mar. 2	108,562	84,944	74,741	88.0	12.0	6.1	.9	2.6	.....	2.4
9	112,368	85,205	78,001	91.5	8.5	2.7	1.1	2.0	.....	2.7
16	115,850	85,487	80,012	93.6	6.4	.4	1.0	2.0	.....	3.0
23	118,959	87,487	82,668	94.5	5.5	.....	.7	2.4	0.2	2.2
30	120,297	87,873	82,440	93.8	6.2	.1	.7	2.9	.....	2.5
Apr. 6	118,628	87,096	81,102	93.1	6.9	.....	.8	2.9	.3	2.9
13	120,622	88,346	83,402	94.4	5.6	.....	.....	3.1	.....	2.5
20	122,834	89,116	83,656	93.9	6.1	.....	.....	3.0	.....	3.1
27	124,051	90,352	85,666	94.8	5.2	.....	.....	2.7	.....	2.5
May 4	125,195	90,969	86,570	95.2	4.8	.....	.8	2.5	.....	1.5
11	133,207	98,349	93,046	94.6	5.4	.....	.8	3.2	.....	1.4
18	132,695	97,451	91,409	93.8	6.2	.....	1.0	4.0	.....	1.2
25	135,873	98,666	93,633	94.9	5.1	.....	.9	3.1	.....	1.1
June 1	135,031	97,954	92,450	94.4	5.6	.....	.9	3.7	.....	1.0
8	136,174	98,603	93,959	95.3	4.7	.....	.9	2.8	.....	1.0
15	136,562	98,883	94,835	95.9	4.1	.....	.....	3.0	.....	1.1
22	137,540	99,464	95,735	96.3	3.7	.....	.....	2.9	.....	.8
29	138,109	98,788	94,283	95.4	4.6	.....	.....	3.3	.....	1.3
July 6	140,822	102,571	96,533	94.1	5.9	.....	.....	2.5	.....	3.4
13	138,577	102,235	95,186	93.1	6.9	.....	.....	3.2	.....	3.7
20	138,010	103,838	98,504	94.9	5.1	.....	.....	3.0	.....	2.1
27	139,410	102,393	96,809	94.5	5.5	.....	.....	3.3	.....	2.2
Aug. 3	145,989	116,787	99,148	84.9	15.1	.....	.....	2.9	.....	12.2
10	151,848	120,141	105,794	88.1	11.9	.....	.....	3.0	.....	8.9
17	170,340	124,138	114,658	92.4	7.6	.....	.....	2.6	.....	5.0
24	168,660	124,777	116,103	93.0	7.0	.....	.....	2.7	.....	4.3
31	170,532	126,378	118,861	94.1	5.9	.....	.....	2.7	.....	3.2
Sept. 7	174,411	126,733	118,864	93.8	6.2	.....	.....	2.8	.....	3.4
14	179,614	131,188	123,102	93.8	6.2	.....	.....	2.6	.2	3.4
21	173,620	128,248	121,425	94.7	5.3	.....	.....	2.1	.....	3.2
28	184,068	132,290	126,352	95.5	4.5	.....	.1	2.4	.....	2.0
Oct. 5	186,896	138,091	133,597	96.7	3.3	.....	.8	2.3	.....	.2
12	188,426	139,286	130,750	93.9	6.1	.....	.8	2.1	.....	3.2
19	182,647	139,256	127,033	91.2	8.8	.....	.7	5.0	.....	3.1
26	188,128	140,949	131,196	93.1	6.9	.....	.5	3.3	.....	3.1
Nov. 2	185,286	143,943	128,964	89.6	10.4	.....	.7	4.6	.....	5.1
9	189,637	144,553	131,429	90.9	9.1	.....	.7	3.1	.....	5.3
16	191,173	145,412	132,801	91.3	8.7	.....	.7	3.0	.....	5.0
23	190,661	147,558	132,567	89.8	10.2	.....	.9	3.4	.....	5.9
30	191,258	147,935	134,014	90.6	9.4	.....	.2	2.3	.....	6.9
Dec. 7	192,119	148,404	135,700	91.4	8.6	.....	.6	2.1	.4	5.5
14	192,516	148,610	134,645	90.6	9.4	.....	.1	2.8	.7	5.8
21	190,823	147,426	132,921	90.2	9.8	.....	.1	3.2	.7	5.8
28	192,068	142,625	132,100	92.6	7.4	.....	.1	3.0	.7	3.6
Total 52 weeks	7,588,045	5,775,872	5,255,436	91.0	9.0	2.2	.4	2.9	.1	3.4

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By-product coke produced in the United States and in several States, 1918, by weeks—Continued.

Pennsylvania.

Week ended—	Coal charged (net tons).	Maximum weekly capacity (net tons).	Coke produced.		Percentage of coke "lost" on account of—					
			Quantity (net tons).	Percentage of capacity.	Total.	No coal.	Labor trouble.	Plant disability.	No demand.	Other causes.
Jan. 5	95,550	92,523	70,900	76.6	23.4	12.2	0.7	7.4	.....	3.1
12	99,085	93,673	79,904	76.2	23.8	14.8	.....	7.8	.....	1.2
19	93,155	93,673	68,000	73.1	26.9	17.7	.....	8.0	.....	1.2
26	90,167	94,987	66,108	69.6	30.4	18.1	.....	10.1	.....	2.2
Feb. 2	86,493	92,367	63,187	68.4	31.6	22.0	.....	8.2	.....	1.4
9	81,715	91,972	59,721	64.9	35.1	26.0	.....	7.5	.....	1.6
16	90,659	91,799	64,403	70.2	29.8	21.0	.....	8.3	.....	.5
23	100,359	91,799	71,648	78.0	22.0	13.0	.....	8.5	.....	.5
Mar. 2	105,371	91,799	75,258	82.0	18.0	8.7	.....	8.8	.....	.5
9	105,285	91,799	75,032	81.7	18.3	8.5	.....	9.8	.....	.....
16	104,987	91,799	75,801	82.6	17.4	7.0	.....	10.2	.....	.2
23	105,238	93,605	76,259	81.5	18.5	6.3	.....	12.0	.....	.2
30	105,801	93,605	78,439	83.8	16.2	4.0	.....	11.9	.....	.3
Apr. 6	102,145	93,605	74,797	79.9	20.1	4.2	5.3	10.6	.....	.....
13	103,316	93,605	74,361	79.4	20.6	7.6	2.9	10.1	.....	.....
20	106,616	93,605	76,495	81.7	18.3	6.4	.4	11.5	.....	.....
27	107,776	93,622	77,804	83.1	16.9	5.1	.....	11.8	.....	.....
May 4	105,977	93,628	76,776	82.0	18.0	3.5	2.6	11.9	.....	.....
11	98,766	93,628	72,157	77.1	22.9	.2	12.2	10.2	.....	.3
18	103,547	93,822	73,628	78.4	21.6	.....	10.7	10.9	.....	.....
25	101,436	93,907	72,629	77.3	22.7	.....	13.0	9.6	.....	.1
June 1	97,660	94,009	69,486	73.9	26.1	.....	16.2	9.9	.....	.....
8	95,923	93,975	68,584	73.0	27.0	.2	16.7	10.1	.....	.....
15	94,466	93,770	67,794	72.3	27.7	.....	17.4	10.3	.....	.....
22	95,027	93,628	69,936	74.7	25.3	.....	15.1	9.9	.....	.3
29	102,485	95,505	74,525	78.0	22.0	.1	11.6	9.6	.....	.7
July 6	109,267	100,128	78,103	78.0	22.0	.....	11.6	10.1	.....	.3
13	115,191	107,578	83,356	77.5	22.5	.....	9.5	10.4	.....	2.6
20	128,370	109,027	88,853	82.4	17.6	.2	7.4	9.4	.....	.6
27	128,911	111,404	91,673	82.3	17.7	.....	7.7	9.6	.....	.4
Aug. 3	138,549	115,110	96,285	83.6	16.4	.....	7.3	9.1	.....	.....
10	140,422	118,252	99,083	84.6	15.4	.....	7.2	7.6	.....	.6
17	142,411	119,270	99,593	83.5	16.5	.....	7.8	8.5	.....	.2
24	148,489	120,864	104,263	86.3	13.7	.....	4.9	8.3	.....	.5
31	149,848	121,346	105,814	87.2	12.8	.....	4.6	7.9	.....	.3
Sept. 7	151,329	122,195	107,172	87.7	12.3	.....	4.4	7.8	.....	.1
14	145,883	122,653	103,658	84.5	15.5	.....	7.4	7.3	.....	.8
21	153,298	126,944	109,157	86.0	14.0	.....	6.5	7.2	.....	.3
28	157,161	127,671	112,782	88.3	11.7	.....	4.3	7.3	.....	.1
Oct. 5	165,287	133,097	117,969	88.6	11.4	.....	3.6	7.5	.....	.3
12	150,871	123,912	107,968	87.1	12.9	.....	.2	9.5	.....	3.2
19	170,945	132,186	120,420	91.1	8.9	.....	.1	8.6	.....	.2
26	165,594	133,499	117,032	87.7	12.3	.....	.8	11.5	.....	.....
Nov. 2	166,971	133,330	118,007	88.5	11.5	.....	1.1	10.3	.....	.1
9	170,273	133,511	118,483	88.7	11.3	.....	1.4	9.8	.....	.1
16	162,464	132,458	113,096	85.4	14.6	2.7	.6	10.9	.....	.4
23	163,807	135,973	113,818	83.7	16.3	2.2	.4	13.7	.....	.....
30	164,711	135,636	115,196	84.9	15.1	2.0	.5	7.1	5.3	.2
Dec. 7	165,789	136,259	116,967	85.8	14.2	.8	.5	6.8	5.9	.2
14	166,860	135,568	117,083	86.4	13.6	.4	.....	7.1	6.1	.....
21	169,406	134,991	118,841	88.0	12.0	.....	.5	7.1	4.3	.1
28	151,501	135,038	101,826	77.6	22.4	.7	.7	7.5	11.2	2.3
Total 52 weeks	6,522,613	5 682,509	4,645,981	81.8	18.2	3.6	4.1	9.2	.8	.5

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By-product coke produced in the United States and in several States, 1918, by weeks—Continued.

Tennessee.

Week ended—	Coal charged (net tons).	Maximum weekly capacity (net tons).	Coke produced.		Percentage of coke "lost" on account of—					
			Quantity (net tons).	Percentage of capacity.	Total.	No coal.	Labor trouble.	Plant disability.	No demand.	Other causes.
Jan. 5	1,330	1,100	1,060	96.4	3.6	.....	.....	3.6	.....	.....
12	1,217	1,100	986	89.6	10.4	.....	.....	.....	.....	10.4
19	1,115	1,100	780	70.9	29.1	.....	.....	29.1	.....	.....
26	1,250	1,100	850	77.3	22.7	.....	.....	22.7	.....	.....
Feb. 2	1,700	2,200	1,250	56.8	43.2	.....	.....	43.2	.....	.....
9	2,450	2,200	1,865	84.8	15.2	.....	.....	15.2	.....	.....
16	2,858	2,200	2,200	100.0	.....	.....	.....	.....	.....	.....
23	2,612	2,220	1,561	70.3	29.7	.....	.....	.....	.....	29.7
Mar. 2	2,682	2,427	2,427	100.0	.....	.....	.....	.....	.....	.....
9	2,982	2,427	2,280	93.9	6.1	.....	.....	.....	.....	6.1
16	2,942	2,350	2,339	99.5	.5	.....	.....	.5	.....	.....
23	3,193	2,422	2,422	100.0	.....	.....	.....	.....	.....	.....
30	3,224	2,947	2,947	100.0	.....	.....	.....	.....	.....	.....
Apr. 6	3,300	2,750	2,750	100.0	.....	.....	.....	.....	.....	.....
13	3,211	2,632	2,632	100.0	.....	.....	.....	.....	.....	.....
20	3,232	2,706	2,706	100.0	.....	.....	.....	.....	.....	.....
27	3,232	2,706	2,706	100.0	.....	.....	.....	.....	.....	.....
May 4	3,525	2,652	2,652	100.0	.....	.....	.....	.....	.....	.....
11	3,130	2,690	2,690	100.0	.....	.....	.....	.....	.....	.....
18	3,212	2,646	2,646	100.0	.....	.....	.....	.....	.....	.....
25	2,942	2,453	2,453	100.0	.....	.....	.....	.....	.....	.....
June 1	2,206	2,458	1,806	73.5	26.5	26.5	.....	.....	.....	.....
8	1,787	2,165	1,357	62.7	37.3	37.3	.....	.....	.....	.....
15	2,750	2,450	1,896	77.4	22.6	22.6	.....	.....	.....	.....
22	3,161	2,237	2,237	100.0	.....	.....	.....	.....	.....	.....
29	3,138	2,266	2,266	100.0	.....	.....	.....	.....	.....	.....
July 6	3,157	2,216	2,216	100.0	.....	.....	.....	.....	.....	.....
13	3,165	2,265	2,265	100.0	.....	.....	.....	.....	.....	.....
20	3,188	2,400	2,400	100.0	.....	.....	.....	.....	.....	.....
27	3,203	2,230	2,230	100.0	.....	.....	.....	.....	.....	.....
Aug. 3	3,380	2,985	2,489	83.4	16.6	.....	.....	.....	.....	16.6
10	3,674	2,985	2,646	88.6	11.4	.....	.....	.....	.....	11.4
17	3,848	2,985	2,815	94.3	5.7	.....	.....	.....	.....	5.7
24	3,985	3,020	3,020	100.0	.....	.....	.....	.....	.....	.....
31	4,015	2,981	2,981	100.0	.....	.....	.....	.....	.....	.....
Sept. 7	3,739	2,797	2,718	97.2	2.8	.....	.....	.....	.....	2.8
14	3,552	2,797	2,581	92.3	7.7	.....	.....	7.7	.....	.....
21	3,698	2,797	2,665	95.3	4.7	.....	.....	4.7	.....	.....
28	3,658	2,797	2,715	97.1	2.9	.....	.....	2.9	.....	.....
Oct. 5	3,485	2,797	2,510	89.7	10.3	.....	.....	10.3	.....	.....
12	3,609	2,797	2,597	92.8	7.2	.....	.....	7.2	.....	.....
19	3,732	2,821	2,821	100.0	.....	.....	.....	.....	.....	.....
26	3,797	2,803	2,803	100.0	.....	.....	.....	.....	.....	.....
Nov. 2	3,805	3,000	2,993	99.8	.2	.....	.....	.....	.....	.2
9	3,695	3,000	2,806	93.5	6.5	.....	.....	.....	.....	6.5
16	3,589	2,797	2,571	91.9	8.1	.....	.....	8.1	.....	.0
23	3,503	2,797	2,658	95.0	5.0	.....	.....	5.0	.....	.....
30	3,524	3,000	2,716	90.5	9.5	.....	.....	9.5	.....	.....
Dec. 7	3,521	3,000	2,718	90.6	9.4	.....	.....	.....	.....	9.4
14	3,560	3,000	2,623	87.4	12.6	.....	.....	.....	.....	12.6
21	3,491	3,000	2,633	87.8	12.2	.....	.....	12.2	.....	.....
28	3,319	3,000	2,418	80.6	19.4	.....	.....	19.4	.....	.....
Total 52 weeks	161,273	131,671	122,372	92.9	7.1	1.5	.....	3.4	.....	2.2

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By-product coke produced in the United States and in several States, 1918, by weeks—Continued.

Washington.

Week ended—	Coal charged (net tons).	Maximum weekly capacity (net tons).	Coke produced.		Percentage of coke "lost" on account of—					
			Quantity (net tons).	Percentage of capacity.	Total.	No coal.	Labor trouble.	Plant disability.	No demand.	Other causes.
Jan. 5	854	589	545	92.5	7.5	.....	.....	.....	.....	7.5
12	854	589	543	92.2	7.8	.....	.....	.....	.....	7.8
19	859	589	548	93.0	7.0	.....	.....	.....	.....	7.0
26	851	589	544	92.4	7.6	.....	.....	.....	.....	7.6
Feb. 2	838	589	537	91.2	8.8	.....	.....	.....	.....	8.8
9	853	589	545	92.5	7.5	.....	.....	.....	.....	7.5
16	733	589	467	79.3	20.7	.....	.....	.....	.....	20.7
23	856	589	546	92.7	7.3	.....	.....	.....	.....	7.3
Mar. 2	933	595	595	100.0	.....	.....	.....	.....	.....	.....
9	956	614	614	100.0	.....	.....	.....	.....	.....	.....
16	947	614	605	98.5	1.5	.....	.....	.....	.....	1.5
23	951	611	611	100.0	.....	.....	.....	.....	.....	.....
30	958	612	612	100.0	.....	.....	.....	.....	.....	.....
Apr. 6	932	595	595	100.0	.....	.....	.....	.....	.....	.....
13	834	602	602	100.0	.....	.....	.....	.....	.....	.....
20	938	598	598	100.0	.....	.....	.....	.....	.....	.....
27	940	600	600	100.0	.....	.....	.....	.....	.....	.....
May 4	935	601	601	100.0	.....	.....	.....	.....	.....	.....
11	935	595	595	100.0	.....	.....	.....	.....	.....	.....
18	910	596	596	100.0	.....	.....	.....	.....	.....	.....
25	938	588	588	100.0	.....	.....	.....	.....	.....	.....
June 1	944	602	602	100.0	.....	.....	.....	.....	.....	.....
8	937	598	598	100.0	.....	.....	.....	.....	.....	.....
15	938	597	597	100.0	.....	.....	.....	.....	.....	.....
22	935	597	597	100.0	.....	.....	.....	.....	.....	.....
29	925	591	591	100.0	.....	.....	.....	.....	.....	.....
July 6	932	595	595	100.0	.....	.....	.....	.....	.....	.....
13	925	590	590	100.0	.....	.....	.....	.....	.....	.....
20	926	591	591	100.0	.....	.....	.....	.....	.....	.....
27	923	589	589	100.0	.....	.....	.....	.....	.....	.....
Aug. 3	921	588	588	100.0	.....	.....	.....	.....	.....	.....
10	930	589	586	99.5	.5	.....	.....	.....	.....	.5
17	930	589	586	99.5	.5	.....	.....	.....	.....	.5
24	922	589	581	98.6	1.4	.....	.....	.....	.....	1.4
31	904	589	570	96.8	3.2	.....	.....	.....	.....	3.2
Sept. 7	917	589	578	98.1	1.9	.....	.....	.....	.....	1.9
14	922	589	580	98.5	1.5	.....	.....	.....	.....	1.5
21	894	589	573	97.3	2.7	.....	.....	.....	.....	2.7
28	866	589	554	94.1	5.9	.....	.....	.....	.....	5.9
Oct. 5	890	589	562	95.4	4.6	.....	.....	.....	.....	4.6
12	865	589	557	94.6	5.4	.....	.....	.....	.....	5.4
19	890	589	563	95.6	4.4	.....	.....	.....	.....	4.4
26	890	589	568	96.4	3.6	.....	.....	.....	.....	3.6
Nov. 2	887	589	565	95.9	4.1	.....	.....	.....	.....	4.1
9	871	589	556	94.4	5.6	.....	.....	.....	.....	5.6
16	892	589	569	96.6	3.4	.....	.....	.....	.....	3.4
23	902	589	575	97.6	2.4	.....	.....	.....	.....	2.4
30	907	589	578	98.1	1.9	.....	.....	.....	.....	1.9
Dec. 7	925	592	592	100.0	.....	.....	.....	.....	.....	.....
14	914	589	583	99.0	1.0	.....	.....	.....	.....	1.0
21	923	589	589	100.0	.....	.....	.....	.....	.....	.....
28	914	589	584	99.2	.8	.....	.....	.....	.....	.8
Total 52 weeks	47,046	30,843	30,074	97.5	2.5	.....	.....	.....	.....	2.5

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By-product coke produced in the United States and in several States, 1918, by weeks—Continued.

West Virginia.

Week ended—	Coal charged (net tons).	Maximum weekly capacity (net tons).	Coke produced.		Percentage of coke "lost" on account of—					
			Quantity (net tons).	Percentage of capacity.	Total.	No coal.	Labor trouble.	Plant disability.	No demand.	Other causes.
Jan. 5	16,354	11,825	11,811	99.9	0.1	.....	.....	.....	.....	0.1
12	15,683	11,415	11,238	98.4	1.6	.....	.....	.....	.....	1.6
19	15,462	11,262	11,232	99.7	.3	.....	.....	.....	.....	.3
26	15,699	11,762	11,720	99.6	.4	.....	.....	.....	.....	.4
Feb. 2	15,305	11,185	11,093	99.2	.8	.....	.....	.....	.....	.8
9	14,851	11,369	10,722	94.3	5.7	.....	.....	.....	.....	5.7
16	15,010	11,279	10,896	96.6	3.4	.....	.....	.....	.....	3.4
23	14,925	14,812	10,794	72.9	27.1	.....	.....	.....	.....	27.1
Mar. 2	15,043	14,812	11,020	74.4	25.6	.....	.....	.....	.....	25.6
9	16,462	14,812	12,087	81.6	18.4	.....	.....	0.1	.....	18.3
16	16,785	14,838	12,358	83.3	16.7	.....	.....	.....	.....	16.7
23	16,731	14,838	12,277	82.7	17.3	.....	.....	.1	.....	17.2
30	16,663	12,198	12,064	98.9	1.1	.....	.....	.7	.....	.4
Apr. 6	16,485	12,198	11,802	96.8	3.2	.....	.....	1.0	.....	2.2
13	16,262	12,198	11,721	96.1	3.9	.....	.....	1.3	.....	2.6
20	16,561	12,198	11,718	96.1	3.9	.....	.....	.6	.....	3.3
27	16,546	12,198	11,868	97.3	2.7	.....	.....	.2	.....	2.5
May 4	16,452	12,199	11,755	96.4	3.6	.....	.....	.....	.....	3.6
11	16,850	12,833	12,442	97.0	3.0	.....	.....	.....	.....	3.0
18	16,850	12,833	11,903	92.8	7.2	.....	.....	4.5	.....	2.7
25	16,725	12,833	11,715	91.3	8.7	.....	.....	5.3	.....	3.4
June 1	16,726	12,833	11,381	88.7	11.3	.....	.....	5.0	.....	6.3
8	16,806	12,833	11,610	90.5	9.5	.....	.....	5.3	.....	4.2
15	16,862	12,833	11,653	90.8	9.2	.....	.....	4.8	.....	4.4
22	16,818	12,833	11,634	90.7	9.3	.....	.....	5.0	.....	4.3
29	16,785	12,833	11,542	89.9	10.1	.....	.....	5.0	.....	5.1
July 6	16,819	12,833	12,031	93.8	6.2	.....	.....	4.8	.....	1.4
13	16,839	12,833	11,986	93.4	6.6	.....	.....	4.8	.....	1.8
20	16,754	12,833	11,794	91.9	8.1	.....	.....	5.3	.....	2.8
27	16,726	12,833	11,790	91.9	8.1	.....	.....	5.2	.....	2.9
Aug. 3	16,671	12,833	11,530	89.8	10.2	.....	.....	5.6	.....	4.6
10	16,606	12,833	11,715	91.3	8.7	.....	.....	6.0	.....	2.7
17	16,575	12,833	11,500	89.6	10.4	.....	.....	5.3	.....	5.1
24	16,567	12,833	11,668	90.9	9.1	.....	.....	6.3	.....	2.8
31	16,480	12,833	11,703	91.2	8.8	.....	.....	5.5	.....	3.3
Sept. 7	16,640	12,833	11,642	90.7	9.3	.....	.....	5.5	.....	3.8
14	16,663	12,833	11,458	89.3	10.7	.....	.....	5.5	.....	5.2
21	16,723	12,823	11,794	92.0	8.0	.....	.....	5.5	.....	2.5
28	16,659	12,833	11,662	90.9	9.1	.....	.....	5.4	.....	3.7
Oct. 5	16,674	12,833	11,856	92.4	7.6	.....	.....	5.6	.....	2.0
12	16,800	12,833	11,988	93.4	6.6	.....	.....	4.8	.....	1.8
19	16,863	12,833	11,860	92.4	7.6	.....	.....	4.5	.....	3.1
26	16,832	12,833	11,917	92.9	7.1	.....	.....	4.5	.....	2.6
Nov. 2	16,776	12,833	11,828	92.2	7.8	.....	.....	5.3	.....	2.5
9	16,700	12,833	11,688	91.1	8.9	.....	.....	5.6	.....	3.3
16	16,487	12,833	10,985	85.6	14.4	.....	.....	7.1	.....	7.3
23	16,848	12,833	11,951	93.1	6.9	.....	.....	4.6	.....	2.3
30	16,631	12,833	11,563	90.1	9.9	.....	.....	6.0	.....	3.9
Dec. 7	16,916	12,833	12,522	97.6	2.4	.....	.....	2.3	.....	.1
14	16,639	12,833	11,835	92.2	7.8	.....	.....	5.9	.....	1.9
21	16,790	12,833	11,770	91.7	8.3	.....	.....	5.0	.....	3.3
28	16,988	12,921	12,308	95.3	4.7	.....	.....	4.7	.....	.....
Total 52 weeks	856,367	663,798	608,400	91.7	8.3	.....	.....	3.4	.....	4.9

SUBSTITUTION OF BY-PRODUCT FOR BEEHIVE COKE.

The story of the gradual replacement of beehive coke by coke made in by-product ovens may be read in the following table, which shows the percentage of the total quantity and value contributed by both types of ovens from 1880 to date. Since the installation of the first by-product ovens at Syracuse, N. Y., in 1893, when a total of 12,850 tons was produced, the rise of the by-product industry has been almost uninterrupted. Up to the beginning of the twentieth century, however, its progress was small, the output in 1900

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amounting to only 5.2 per cent of the total production of coke. In 1905 it had risen to 10.7 per cent; in 1910 to 17.1 per cent; in 1913, the last year before the World War, to 27.5 per cent. Under the stimulus of the wartime demand for benzol and toluol rapid progress in the substitution of by-product coke for beehive coke was made. The beehive industry reached its maximum in 1916, with a total of 35,464,000 tons, or 65 per cent of the entire output. Thereafter the production of beehive coke steadily declined; from 1916 to 1918 it decreased nearly 5,000,000 tons, amounting in 1918 to 54 per cent of the entire output. In the meantime the production of by-product coke had increased amazingly, and in 1918 it constituted 46 per cent of the total.

The proportion of the value assignable to by-product coke was even larger—50.5 per cent in 1918. As the value is reckoned at the ovens, the price per ton of by-product coke contains an element which represents the cost of transporting the coal from the mine to the point of consumption and which is not included in the average price of beehive coke.

Coke produced in the United States, 1880–1918.

Year.	By-product coke.				Beehive coke.				Total.	
	Quantity (net tons).	Percentage to total.	Value.	Percentage to total.	Quantity (net tons).	Percentage to total.	Value.	Percentage to total.	Quantity (net tons).	Value.
1880	0	0	0	0	3,338,300	100.0	$6,631,267	100.0	3,338,300	$6,631,267
1885	0	0	0	0	5,106,696	100.0	7,629,118	100.0	5,106,696	7,629,118
1890	0	0	0	0	11,508,021	100.0	23,215,302	100.0	11,508,021	23,215,302
1893	12,850	0.1	(a)	(a)	9,464,730	99.9	(a)	(a)	9,477,580	16,523,714
1900	1,075,727	5.2	$2,635,531	5.6	19,457,621	94.8	44,807,800	94.4	20,533,348	47,443,331
1905	3,462,348	10.7	10,851,730	15.0	28,768,781	89.3	61,624,466	85.0	32,231,129	72,476,196
1910	7,138,734	17.1	24,793,016	24.9	34,570,076	82.9	74,949,685	75.1	41,708,810	99,742,701
1911	7,847,845	22.1	27,297,897	32.4	27,703,644	77.9	56,832,952	67.6	35,551,489	84,130,849
1912	11,115,164	25.3	42,632,930	38.1	32,868,435	74.7	69,172,183	61.9	43,983,599	111,805,113
1913	12,714,700	27.5	48,637,852	37.7	33,584,830	72.5	80,284,421	62.3	46,299,530	128,922,273
1914	11,219,943	32.5	38,080,167	43.1	23,335,971	67.5	50,254,050	56.9	34,555,914	88,334,217
1915	14,072,895	33.8	48,558,325	46.0	27,508,255	66.2	56,945,543	54.0	41,581,150	105,503,868
1916	19,069,361	35.0	75,372,070	44.1	35,464,224	65.0	95,468,127	55.9	54,533,585	170,841,197
1917	22,439,280	40.4	138,643,153	46.5	33,167,548	59.6	159,599,864	53.5	55,606,828	298,243,017
1918	25,997,580	46.0	193,018,785	50.5	30,480,792	54.0	189,305,583	49.5	56,478,372	382,324,368

a Figures not available.

Statistics of the manufacture of coke in the United States, 1880–1918.

Year.	In operation.		Coal used (net tons).	Per centage yield of coke from coal.	Coke produced (net tons).	Total value of coke at ovens.	Value of coke at ovens per ton.
	Establishments.	Ovens.					
1880	a 186	a 12,372	5,237,741	63.7	3,338,300	$6,631,267	$1.99
1890	a 253	a 37,158	18,005,209	64.9	11,508,021	23,215,302	2.02
1900	345	43,039	32,113,553	63.9	20,533,348	47,443,331	2.31
1910	478	96,067	63,088,327	66.1	41,708,810	99,742,701	2.39
1911	391	63,480	53,278,248	66.7	35,551,489	84,130,849	2.37
1912	439	73,058	65,577,862	67.1	43,983,599	111,805,113	2.54
1913	444	72,008	69,239,190	66.9	46,299,530	128,922,273	2.78
1914	359	54,638	51,623,750	66.3	34,555,914	88,334,217	2.56
1915	354	54,967	61,832,898	67.2	41,581,150	105,503,868	2.54
1916	389	72,888	81,609,460	66.8	54,533,585	170,841,197	3.13
1917	398	75,985	83,752,371	66.4	55,606,828	298,243,017	5.36
1918	403	70,221	85,028,018	66.4	56,478,372	382,324,368	6.77

a Total in existence. No statistics available showing idle establishments.

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RANK OF STATES IN PRODUCTION OF COKE.

The five leading producers of coke in 1918, in order of output, were Pennsylvania, Ohio, Alabama, Indiana, and West Virginia. The gradual encroachment of the by-product ovens has caused striking changes in the rank of individual States, even in the last five years. Pennsylvania has from the earliest times occupied first place as a producer of coke. Although her supremacy as the leading producer of all coke has not been challenged, in 1918 she lost first place as a producer of by-product coke to Ohio, which in 1914 occupied ninth place and in 1917 had risen to second place. Ohio has also forged rapidly upward in total production from eleventh place in 1914 to second place in 1918. Alabama, occupying in 1914 second place in point of total production and third place in output of by-product coke, fell in 1918 to third place in total output and fourth in by-product output.

Rank of the States in the production of coke, 1914–1918.

State.	1914		1915		1916		1917		1918	
	Total.	By-product.	Total.	By-product.	Total.	By-product.	Total.	By-product.	Total.	By-product.
Pennsylvania	1	1	1	1	1	1	1	1	1	2
Ohio	11	9	7	7	6	5	3	2	2	1
Alabama	2	3	2	3	2	3	2	4	3	4
Indiana	3	2	3	2	3	2	4	3	4	3
West Virginia	5	14	5	13	4	15	5	12	5	11
Illinois	4	4	4	4	5	4	6	5	6	5
Virginia	6	.....	10	.....	7	.....	7	.....	7	.....
New York	12	8	8	6	11	7	9	6	8	6
Michigan	9	6	6	5	10	6	11	8	9	7
Wisconsin	8	5	11	8	12	8	10	7	10	8
Colorado	7	.....	9	.....	8	.....	8	.....	11	16
Kentucky	13	11	12	12	9	12	12	10	12	13
Minnesota	18	12	21	15	16	11	16	13	13	9
New Jersey	17	10	17	11	20	14	17	14	14	10
New Mexico	14	.....	14	.....	14	.....	14	.....	15	.....
Massachusetts	10	7	13	9	13	9	13	9	16	12
Maryland	19	13	16	10	15	10	15	11	17	14
Tennessee	16	.....	18	17	18	16	18	16	18	17
Utah	15	.....	15	.....	17	.....	19	.....	19	.....
Missouri	.....	.....	20	14	19	13	20	15	20	15
Washington	20	15	19	16	21	17	21	17	21	18
Oklahoma	.....	.....	.....	.....	.....	.....	.....	.....	22	.....
Georgia	21	.....	22	.....	22	.....	22	.....	23	.....

COKE IN PENNSYLVANIA.

Pennsylvania, though yielding to Ohio the first place in production of by-product coke in 1918, continued to be by far the largest producer in terms of all coke. The southward and westward extension of the iron industry, carrying with it the manufacture of both beehive and by-product coke, has, however, deprived Pennsylvania of the virtual monopoly she held in the early days. In 1880 the State produced 85 per cent of the country's total output. By 1900 the proportion had fallen to 65 per cent, in 1915 it was 62 per cent, and thereafter it steadily declined. As late as 1917 the State contributed one-half of the country's total supply of coke. In 1918, however, production in Pennsylvania declined both relatively and absolutely and constituted but 47.3 per cent of the total output of the country. These percentages taken by themselves fail to do

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justice to the position of Pennsylvania in the coke industry, for in addition to her coke, she supplies much of the raw coal required by the by-product ovens in adjoining States.

The total production of all coke in Pennsylvania in 1918 amounted to 26,723,645 tons, a decrease as compared with the output in 1917 of 1,188,380 tons, or 4 per cent. There was an increase in the State's output of by-product coke, but it was more than offset by the decline in beehive coke. Under the stimulus of the high prices prevailing in 1918 the value of the product increased, rising from $135,698,000 in 1917 to $160,357,000 in 1918.

The quantity of beehive coke produced in 1918 is reported at 22,136,664 tons, a decrease from 1917 of 1,679,756 tons, or 7.1 per cent. Practically every district was affected by the decrease. Production in the Connellsville and Lower Connellsville districts is reported to the Geological Survey at 17,262,987 tons, or 78 per cent of the total of the State, about the same proportion as that contributed in 1917. Monthly shipments out of the Connellsville region, as recorded by the Connellsville Courier, are shown in the accompanying table. The number of beehive ovens also declined. In 1917 it had been 49,949; a year later it was 48,588, every district but one reporting a decrease. The average yield of coke from the coal charged in beehive ovens was practically the same—65 per cent, as against 65.1 per cent in 1917.

The construction of new retort ovens made possible an increase in the output of by-product coke, which amounted to 4,586,981 tons in 1918, an increase of 12 per cent over the output in 1917. Operations at the great Clairton plant of the Carnegie Steel Co. began in a preliminary way in June, 1918. Originally designed to include 640 Koppers ovens, the plant is to be enlarged by the construction of 128 additional ovens. This plant is the largest of its kind in the United States, if not in the world. Extensions at other existing plants were made at Johnstown and Steelton. The increase in output in 1918 was limited to the Pittsburgh district, which includes the Clairton plant. The output in that district amounted to 2,389,698 tons. The average yield of coke per ton of coal charged in by-product ovens declined from 71.6 to 70.4 per cent.

Coke produced in Pennsylvania, 1880–1918.

Year.	Establishments.	Ovens.		Coal used (net tons).	Yield of coke from coal (per cent).	Coke produced (net tons).	Total value of coke at ovens.	Value of coke at ovens, per ton.
		Built.	Under construction.					
1880	124	2,501	836	4,347,558	64.9	2,821,384	$5,255,042	$1.86
1890	106	23,430	74	13,046,143	65.6	8,560,245	16,333,674	1.91
1900	177	32,545	2,310	20,239,966	66.0	13,357,295	29,692,258	2.22
1910	288	55,656	1,334	39,455,785	66.7	26,315,607	55,254,599	2.10
1911	279	54,904	1,271	32,875,655	66.7	21,923,935	43,053,367	1.96
1912	277	53,756	1,887	41,268,532	66.5	27,438,693	56,336,255	2.05
1913	276	55,058	582	43,195,801	66.6	28,753,444	67,929,864	2.36
1914	274	54,075	867	30,286,961	66.9	20,258,393	42,447,886	2.10
1915	273	54,856	752	38,273,744	66.9	25,622,862	52,617,018	2.06
1916	251	54,372	710	46,950,086	66.6	31,279,695	84,710,305	2.71
1917	240	51,905	703	42,310,784	66.0	27,912,025	135,698,040	4.86
1918	230	[a] 50,956	[b] 698	40,573,894	65.9	26,723,645	160,357,274	6.00

[a] Includes 675 United-Otto, 1,216 Koppers, 360 Semet-Solvay, 27 Gas Machinery, and 90 Cambria ovens.
[b] Includes 578 Koppers and 60 Cambria ovens.

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Beehive coke produced in Pennsylvania in 1917 and 1918.

1917.

District.	Establishments.	Ovens. Built.	Ovens. Under construction.	Coal used (net tons).	Yield of coke from coal (per cent).	Coke produced (net tons).	Value of coke at ovens per ton.[a]
Allegheny Mountain and Allegheny Valley	8	810	3	349,858	66.5	232,703	$4.44
Connellsville	100	20,974	.....	15,388,687	66.5	10,230,909	3.95
Lower Connellsville	74	16,420	.....	12,785,016	65.3	8,348,727	4.85
Pittsburgh	11	3,951	.....	4,098,668	60.3	2,471,587	6.08
Upper Connellsville	15	2,314	.....	1,117,491	65.3	730,199	5.81
Other districts [b]	24	5,480	.....	2,854,843	63.1	1,802,295	5.58
	232	49,949	3	36,594,563	65.1	23,816,420	4.67

1918.

Allegheny Mountain and Allegheny Valley	8	770	.....	341,126	64.9	221,250	$7.17
Connellsville	95	20,365	.....	14,325,959	66.3	9,501,692	5.44
Lower Connellsville	71	16,234	.....	11,875,495	65.4	7,761,295	6.28
Pittsburgh	10	3,711	.....	3,871,162	62.0	2,401,392	5.81
Upper Connellsville	13	2,028	.....	961,131	66.7	641,236	6.90
Other districts [b]	24	5,480	60	2,684,153	60.0	1,609,799	6.49
	221	48,588	60	34,059,026	65.0	22,136,664	6.00

[a] Average value of all coke produced including estimated value of coke used by producer; 1918, average price realized on coke sold.
[b] Includes Bedford, Cameron, Clearfield, Elk, Huntingdon, Jefferson, and parts of Allegheny, Indiana, and Westmoreland counties.

Coke shipped from the Connellsville and Lower Connellsville districts, 1914–1918, in net tons.

Month.	1914	1915	1916	1917	1918
January	1,222,282	940,781	1,793,951	1,564,173	1,021,055
February	1,270,107	1,045,739	1,781,068	1,288,763	991,871
March	1,594,267	1,258,559	2,038,812	1,618,969	1,436,821
April	1,423,048	1,268,292	1,861,290	1,558,247	1,459,248
May	1,198,651	1,310,639	1,937,404	1,649,989	1,532,634
June	1,129,821	1,486,845	1,842,521	1,563,616	1,438,700
July	1,189,834	1,618,199	1,748,365	1,539,931	1,578,130
August	1,157,942	1,657,203	1,806,422	1,554,935	1,492,065
September	1,112,653	1,683,414	1,771,405	1,464,200	1,423,236
October	1,028,764	1,851,938	1,768,800	1,509,903	1,410,403
November	823,595	1,873,405	1,719,715	1,350,374	1,136,355
December	924,674	1,926,202	1,584,749	1,221,257	1,160,072
	14,075,638	17,921,216	21,654,502	17,884,357	16,080,590

By-product coke produced in Pennsylvania in 1917 and 1918.

1917.

District.	Establishments.	Ovens. Built.	Ovens. Under construction.	Coal used (net tons).	Yield of coke from coal (per cent).	Coke produced (net tons).	Value of coke at ovens per ton.[a]
Pittsburgh [b]	3	794	640	2,516,433	70.4	1,770,468	$5.58
Other districts [c]	6	1,162	60	3,199,788	72.7	2,325,137	6.26
	9	1,956	700	5,716,221	71.6	4,095,605	5.97

[a] Average value of all coke produced including estimated value of coke used by producer.
[b] Includes plants at Clairton, Farrell, Glassport, and Johnstown.
[c] Includes plants at Chester, Dunbar, Lebanon, South Bethlehem, and Steelton.

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By-product coke produced in Pennsylvania in 1917 and 1918—Continued.

1918.

District.[a]	Establishments.	Ovens. Built.	Ovens. Under construction.	Coal used (net tons).	Yield of coke from coal (per cent).	Coke produced (net tons).	Value of coke at ovens per ton.[a]
Pittsburgh [b]	4	1,524	528	3,516,050	68.0	2,389,698	$5.73
Other districts [c]	5	844	110	2,998,818	73.3	2,197,283	6.09
	9	2,368	638	6,514,868	70.4	4,586,981	6.46

[a] Average price realized on coke sold.
[b] Includes plants at Glassport, Johnstown, Clairton, and Farrell, and plants under construction at Pittsburgh and Midland.
[c] Includes plants at South Bethlehem, Lebanon, Steelton, Chester, and Dunbar, and plant under construction at Swedeland.

COKE IN WEST VIRGINIA.

The total output of coke in West Virginia declined slightly from 1917 to 1918, an increase of 18 per cent in the production of by-product coke being more than offset by a decline of 4.3 per cent in beehive coke. The total output of all coke is reported at 3,320,006 tons.

Beehive coke is produced in West Virginia in five distinct localities. Three of them—the Flat Top-Tug River district, the Kanawha district, and the New River district—are in the southern part of the State. The coal used is a low-volatile coal of excellent coking quality. The yields from the coal charged are small however, amounting to 58 or 59 per cent, as compared with the 67.6 per cent, for example, obtained in the Upper Potomac and Tygarts Valley fields, where the coal used is a high-volatile coal. It was in the Flat Top-Tug River district that the production of beehive coke decreased; in other districts a slight increase was reported.

The by-product coke plants of West Virginia lie in the Panhandle. There was no increase in number of ovens in operation in 1918, but 120 additional ovens were under construction at the end of the year. The total production was 603,393 tons, an increase of 92,360 tons as compared with the output in 1917.

Coke produced in West Virginia in 1917 and 1918.

1917.

District.	Establishments.	Ovens. Built.	Ovens. Under construction.	Coal used (net tons).	Yield of coke from coal (per cent).	Coke produced (net tons).	Value of coke at ovens per ton.[a]
Beehive:							
Flat Top	37	6,399	20	2,881,167	58.0	1,672,407	$4.55
Tug River	1	2,151	.....				
Kanawha	7	1,374	.....	390,895	59.0	230,671	5.07
New River	13	1,297	.....	345,587	59.5	205,688	7.12
Upper Monongahela and Panhandle	24	2,328	.....	842,677	62.9	530,349	5.69
Upper Potomac and Tygarts Valley	8	765	.....	293,990	67.9	199,613	5.99
By-product:							
Benwood and Follansbee	2	[b] 214	.....	727,778	70.2	511,033	4.43
	92	14,528	20	5,482,094	61.1	3,349,761	4.99

[a] Average value of all coke produced, including estimated value of coke used by producer.
[b] Includes 120 Semet-Solvay and 94 Koppers ovens.

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Coke produced in West Virginia in 1917 and 1918—Continued.

1918.

District.	Establishments.	Ovens. Built.	Ovens. Under construction.	Coal used (net tons).	Yield of coke from coal (per cent).	Coke produced (net tons).	Value of coke at ovens per ton.[a]
Beehive:							
Flat Top	36	6,315	.....	2,418,371	59.3	1,433,736	$5.91
Tug River	1	2,137	.....				
Kanawha	7	1,374	.....	435,475	58.2	253,258	6.57
New River	14	1,298	.....	395,663	59.0	233,520	8.10
Upper Monongahela and Panhandle	23	2,241	.....	960,924	61.3	589,342	6.90
Upper Potomac and Tygarts Valley	8	765	.....	305,675	67.6	206,757	6.73
By-product:							
Benwood and Follansbee	2	[b] 214	[c] 120	853,684	70.7	603,393	7.84
	91	14,344	120	5,369,792	61.8	3,320,006	6.67

[a] Average price realized on coke sold.
[b] Includes 120 Semet-Solvay and 94 Koppers ovens.
[c] Includes 60 Semet-Solvay and 60 Koppers ovens.

COKE IN OHIO.

The State of Ohio has long been the center of a small beehive-coke industry but the production which amounted to 139,000 tons in 1918, is practically constant. It centers at Leetonia and other localitities, and the output is consumed locally.

The by-product coke industry in Ohio, however, has grown by leaps and bounds. The State has risen from ninth place as a producer of by-product coke in 1914 to first place in 1918. The change is in essence a migration from the mines of western Pennsylvania in the direction of the Lake front, at which shipments of ore coming down the Lakes are unloaded. The quantity of ore coming down the Lakes has been in excess of the quantity of coal moving up the Lakes, and the establishment of iron furnaces and coke ovens along the route from mine to Lake front, or even on the Lake front itself, has been in part the result of economic pressure to equalize these freight movements.

The total output of by-product coke in Ohio in 1918 was 5,226,334 tons, an increase over that of 1917 of 1,679,858 tons, or 47 per cent.

As shown in the accompanying table, there was an increase in each of the major producing districts, notably in the district outside of Canton, Cleveland, and Youngstown. New plants beginning operations in 1918 included the American Steel & Wire Co.'s plant at Cleveland, with 180 Koppers ovens, which began in April; the plant of the Ironton Solvay Coke Co. at Ironton, with 60 Semet-Solvay ovens; and the plant of the National Tube Co. at Lorain, with 208 Koppers ovens, both of which began in August. The Youngstown Sheet & Tube Co. added 102 new ovens to its existing battery of 204.

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By-product coke produced in Ohio in 1916, 1917, and 1918.

1916.

District.	Establishments.	Ovens.		Coal used (net tons).	Yield of coke from coal (per cent).	Coke produced (net tons).	Value of coke at ovens per ton.a
		Built.	Under construction.				
Canton and Cleveland	3	351	180	602,827	68.0	410,218	$4.04
Youngstown	2	347	84	1,337,758	68.7	919,367	3.74
Other districts	3	218	208	507,227	72.9	369,581	3.77
	8	916	472	2,447,812	69.4	1,699,166	3.82

1917.

Canton and Cleveland	3	351	180	1,883,796	70.1	1,320,146	7.13
Youngstown	3	431	312	2,520,027	68.7	1,730,942	5.70
Other districts	4	326	268	737,223	67.2	495,388	6.19
	10	1,108	760	5,141,046	69.0	3,546,476	6.30

1918.

Canton and Cleveland	4	531	.....	2,737,188	66.5	1,821,334	7.93
Youngstown	3	533	.....	2,992,778	67.7	2,024,875	5.49
Other districts	6	594	.....	2,045,657	67.5	1,380,125	6.70
	13	1,658	.....	7,775,623	67.2	5,226,334	6.82

a 1916, 1917, average value of all coke produced, including estimated value of coke used by producer; 1918, average price realized on coke sold.

COKE OVENS IN THE UNITED STATES.

INCREASE IN BY-PRODUCT OVENS.

The number of beehive ovens[1] in the United States has been decreasing for years, irrespective of the fluctuations in the production of coke. By-product ovens, on the contrary, have increased in number each year since 1894. The greater advantages and economies of the newer process will continue to operate in the further decrease in beehive ovens.

The history of the construction of beehive and by-product ovens in the United States is shown in figures 134 and 135 and by the tables on the following pages. The reports to the United States Geological Survey by the operators cover the number of ovens in existence and being built at the end of each year and the number abandoned during each year. Beehive ovens may be completely constructed during the 12-month period, or they may be abandoned, and the total shown for any year therefore does not necessarily represent the total of those in existence at the end of the previous year plus the number reported as under construction. Some beehive ovens in Kansas have been idle for years, but they are reported to the Geological Survey as idle, not as abandoned. In all probability, however, few of these ovens will ever be operated again.

The first by-product ovens were constructed in the United States in 1893, and since 1894 not a year has passed without additions to the number in operation. The number of ovens under construction

[1] With beehive ovens are included the rectangular ovens and all modified types in which partial combustion of the coal takes place and no by-products are saved.

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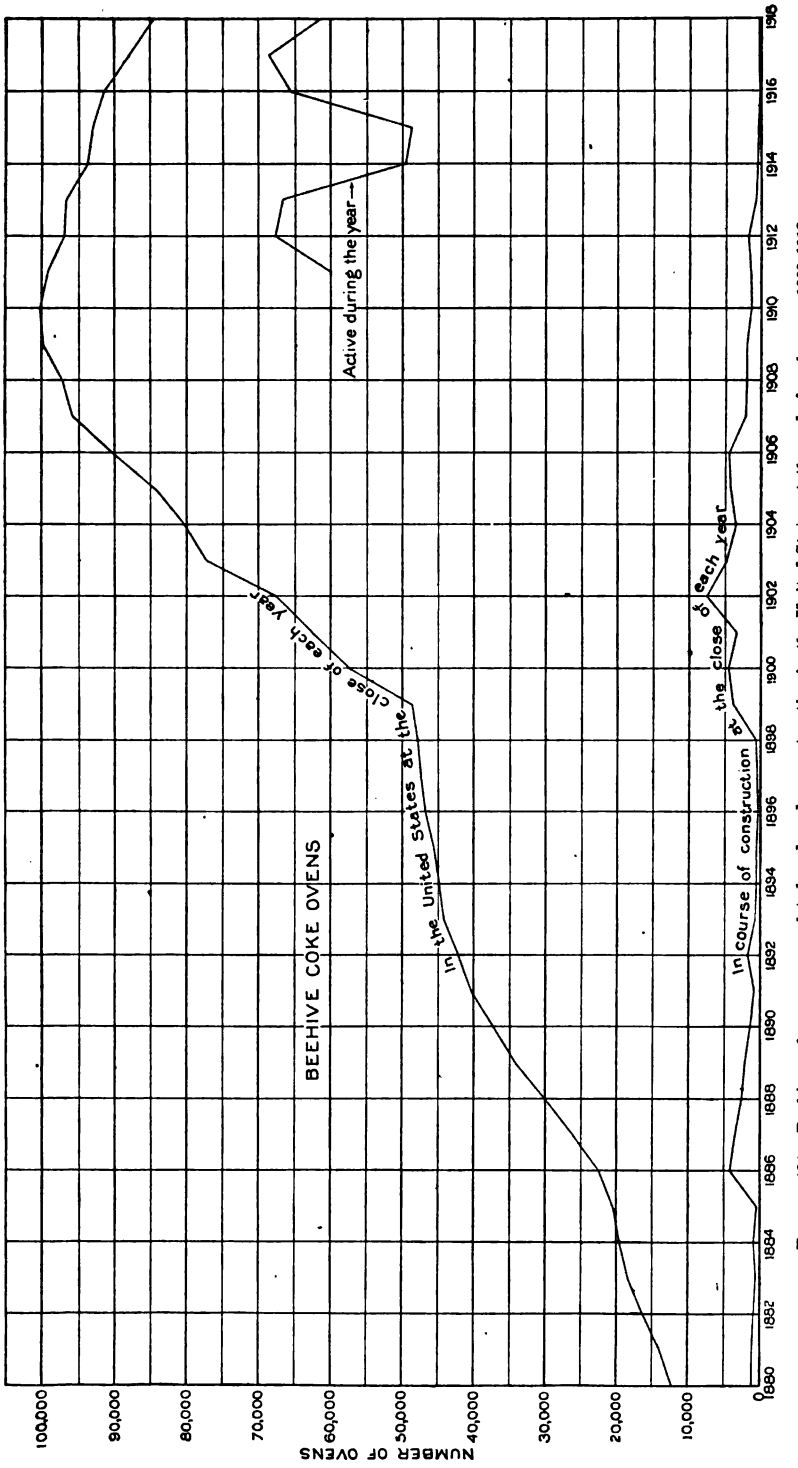

FIGURE 134.—Beehive coke ovens completed and under construction in the United States at the end of each year, 1880–1918.

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and the total built at the end of each year are shown graphically in figure 135, and it is interesting to compare these curves with that in figure 133 showing the annual output from these ovens for the same period. Prior to the World War the greatest activity in construction was in the years 1901 and 1910. In 1900 there were 1,096 ovens being built, 80 of which were completed in 1901. In 1901 there were 1,533 ovens, including 1,005 reported in 1900, under construction, 502 of which were put into operation in 1902. This activity was confined mainly to Alabama, Maryland, New York, and Pennsylvania, and most of the ovens built at this time were of the Otto-Hoffman or modified types. Between 1903 and 1909 there was a lull in the construction of by-product ovens. In 1909 large installations of Koppers ovens at Gary, Ind., and of Didier ovens at South Bethlehem, Pa., were begun, but as they were not completed in 1910 they are shown as under construction in the record for that year also. The number of by-product ovens under construction reached a maximum of 2,260 at the end of 1917. On December 31, 1918, the number under construction was 1,815. The number of completed ovens has increased at a rapid rate, the only period in which progress was slow having been in the years 1906 to 1910.

Figure 134 shows the number of completed beehive ovens at the end of each year for the period from 1880 to 1918. The number of beehive ovens under construction at the end of each year is also shown,

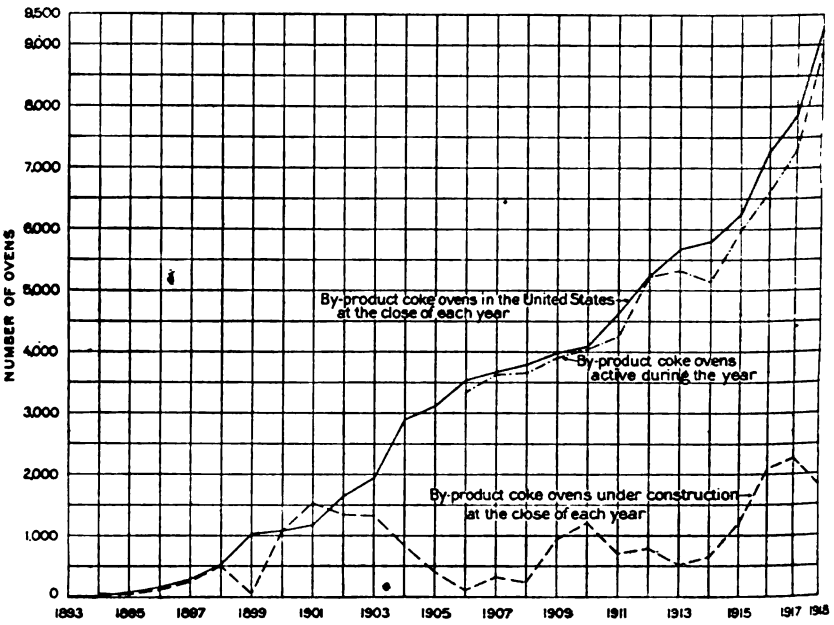

FIGURE 135.—By-product ovens completed and under construction in the United States at the end of each year, 1893–1918, and by-product ovens active during the years 1906–1918.

but it is evident that this record is a very poor index of activity; for, as has been previously noted, beehive ovens are constructed in a comparatively short time and abandoned with equal facility, and an annual statement of those in process of erection furnishes little real information.

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From 1880 to 1893 steady progress was made in the erection of beehive ovens, but from 1894 to 1899 there were few additions. From 1900 to 1907, a period of great industrial expansion, particularly in the iron and steel business, the number of beehive ovens increased rapidly, and in 1910 the highest number was reached—the same year, it will be noted, that recorded a large number of by-product ovens under construction. Each succeeding year since 1910 has shown a decrease in beehive ovens, and in view of the present activity in the construction of by-product ovens, there is no reason to expect otherwise than that the trend will continue downward.

Coke ovens in the United States, 1917 and 1918.

1917.

State.	Active.		Idle.		Total.		Abandoned.		Under construction at end of year.	
	Beehive.	By-product.	Beehive.	By-product.	Beehive.	By-product.	Beehive.	By-product.	Beehive.	By-product.
Alabama	5,493	831	3,320	16	8,813	847	1	.....	.....	.....
Colorado	2,867	.....	706	.....	3,573	.....	.....	.....	.....	120
Georgia	151	.....	50	.....	201	.....	.....	.....	.....	.....
Illinois	.....	619	.....	7	.....	626	.....	.....	.....	.....
Indiana	.....	861	.....	25	.....	886	.....	.....	.....	260
Kansas	.....	.....	2	.....	2	.....	.....	.....	.....	.....
Kentucky	801	108	296	.....	1,097	108	.....	.....	.....	.....
Maryland	.....	120	.....	.....	.....	120	.....	.....	.....	240
Massachusetts	.....	317	.....	83	.....	400	.....	.....	.....	.....
Michigan	.....	258	.....	11	.....	269	.....	.....	.....	.....
Minnesota	.....	152	.....	3	.....	155	.....	.....	.....	65
Missouri	.....	56	.....	.....	.....	56	.....	.....	.....	.....
New Jersey	.....	260	.....	.....	.....	260	.....	.....	.....	55
New Mexico	1,134	.....	70	.....	1,204	.....	.....	.....	.....	.....
New York	.....	615	.....	.....	.....	615	.....	.....	.....	.....
Ohio	198	1,009	134	99	332	1,108	.....	.....	.....	760
Oklahoma	.....	.....	50	.....	50	.....	.....	.....	.....	.....
Pennsylvania	44,534	1,629	5,415	327	49,949	1,956	3,430	.....	3	700
Tennessee	1,266	12	962	.....	2,228	12	.....	.....	100	24
Utah	726	.....	.....	.....	726	.....	.....	.....	93	.....
Virginia	3,029	.....	1,950	.....	4,979	.....	191	.....	100	.....
Washington	254	5	77	.....	331	5	.....	.....	66	.....
West Virginia	8,234	214	6,080	.....	14,314	214	1,199	.....	20	.....
Wisconsin	.....	232	228	.....	228	232	.....	.....	.....	36
	68,687	7,298	19,340	571	88,027	7,869	4,821	.....	382	2,260

1918.

Alabama	5,570	807	3,016	40	8,586	847	278	.....	49	324
Colorado	1,431	120	1,293	.....	2,724	120	849	.....	.....	.....
Georgia	101	.....	100	.....	201	.....	.....	.....	.....	.....
Illinois	.....	605	.....	21	.....	626	.....	.....	.....	88
Indiana	.....	945	.....	81	.....	1,026	.....	.....	.....	190
Kansas	.....	.....	2	.....	2	.....	.....	.....	.....	.....
Kentucky	798	108	279	.....	1,077	108	20	.....	50	.....
Maryland	.....	180	.....	.....	.....	180	.....	.....	.....	180
Massachusetts	.....	400	.....	.....	.....	400	.....	.....	.....	.....
Michigan	.....	269	.....	.....	.....	269	.....	.....	.....	120
Minnesota	.....	214	.....	6	.....	220	.....	.....	.....	.....
Missouri	.....	56	.....	.....	.....	56	.....	.....	.....	.....
New Jersey	.....	260	.....	.....	.....	260	.....	.....	.....	55
New Mexico	1,053	.....	101	.....	1,154	.....	50	.....	.....	.....
New York	.....	615	.....	.....	.....	615	.....	.....	.....	60
Ohio	198	1,610	74	48	272	1,658	60	.....	.....	.....
Oklahoma	304	.....	.....	.....	304	.....	50	.....	.....	.....
Pennsylvania	37,730	2,189	10,858	179	48,588	2,368	943	376	60	638
Rhode Island	.....	.....	.....	.....	.....	.....	.....	.....	.....	40
Tennessee	1,101	24	1,227	.....	2,328	24	.....	12	90	.....
Utah	819	.....	.....	.....	819	.....	.....	.....	.....	.....
Virginia	3,135	.....	907	.....	4,042	.....	988	.....	120	.....
Washington	250	20	158	.....	408	20	25	.....	.....	.....
West Virginia	8,827	214	5,303	.....	14,130	214	242	.....	.....	120
Wisconsin	.....	268	.....	.....	.....	268	228	.....	.....	.....
	61,317	8,901	23,318	375	84,635	9,279	3,733	388	369	1,815

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Beehive coke ovens at end of each year, 1914–1918.

State.	1914	1915	1916	1917	1918
Alabama	8,535	8,568	8,806	8,813	8,598
Colorado	3,573	3,573	3,573	3,573	2,724
Georgia	201	201	201	201	201
Kansas	2	2	2	2	2
Kentucky	1,097	1,097	1,097	1,097	1,077
Montana	351	112	.....	.....	2
New Mexico	1,030	1,030	1,060	1,204	1,154
Ohio	321	321	321	332	272
Oklahoma	260	50	50	50	304
Pennsylvania	52,553	53,112	52,416	49,949	48,598
Tennessee	2,303	2,302	2,228	2,228	2,328
Utah	726	726	726	726	819
Virginia	5,435	5,229	5,146	4,979	4,042
Washington	331	331	331	331	408
West Virginia	17,000	16,228	15,396	14,314	14,130
Wisconsin	228	228	228	228	.....
	93,946	93,110	91,581	88,027	84,635

By-product ovens in the United States at the end of the year in 1917 and 1918.

1917.

State.	Koppers.	United-Otto.[a]	Semet-Solvay.	Rothberg.	Didier.	Gas machinery.	Roberts fluelees.	Klönne.	Wilputte.	Total.
Alabama	487	.....	300	.....	.....	.....	.....	.....	60	847
Illinois	315	.....	293	.....	.....	.....	.....	.....	18	626
Indiana	600	100	41	.....	.....	33	.....	22	.....	886
Kentucky	.....	.....	108	.....	.....	.....	.....	.....	.....	108
Maryland	120	.....	.....	.....	.....	.....	.....	.....	.....	120
Massachusetts	.....	400	.....	.....	.....	.....	.....	.....	.....	400
Michigan	.....	54	215	.....	.....	.....	.....	.....	.....	269
Minnesota	90	65	.....	.....	.....	.....	.....	.....	.....	155
Missouri	56	.....	.....	.....	.....	.....	.....	.....	.....	56
New Jersey	110	150	.....	.....	.....	.....	.....	.....	.....	260
New York	.....	188	146	281	.....	.....	.....	.....	.....	615
Ohio	776	100	208	.....	.....	.....	24	.....	.....	1,108
Pennsylvania	636	903	240	.....	150	27	.....	.....	.....	1,956
Tennessee	.....	.....	.....	.....	.....	.....	12	.....	.....	12
Washington	.....	.....	.....	.....	.....	.....	.....	5	.....	5
West Virginia	94	.....	120	.....	.....	.....	.....	.....	.....	214
Wisconsin	.....	72	160	.....	.....	.....	.....	.....	.....	232
	3,374	2,032	1,831	281	150	60	36	27	78	7,869

1918.

Alabama	487	.....	300	.....	.....	.....	.....	.....	60	847
Colorado	120	.....	.....	.....	.....	.....	.....	.....	.....	120
Illinois	315	.....	293	.....	.....	.....	.....	.....	18	626
Indiana	830	100	41	.....	.....	33	.....	22	.....	1,026
Kentucky	.....	.....	108	.....	.....	.....	.....	.....	.....	108
Maryland	180	.....	.....	.....	.....	.....	.....	.....	.....	180
Massachusetts	.....	400	.....	.....	.....	.....	.....	.....	.....	400
Michigan	.....	54	215	.....	.....	.....	.....	.....	.....	269
Minnesota	155	65	.....	.....	.....	.....	.....	.....	.....	220
Missouri	56	.....	.....	.....	.....	.....	.....	.....	.....	56
New Jersey	110	150	.....	.....	.....	.....	.....	.....	.....	260
New York	.....	188	146	281	.....	.....	.....	.....	.....	615
Ohio	1,266	100	268	.....	.....	.....	24	.....	.....	1,658
Pennsylvania	1,216	675	360	.....	90	27	.....	.....	.....	2,368
Tennessee	.....	.....	24	.....	.....	.....	.....	.....	.....	24
Washington	.....	.....	.....	.....	.....	.....	.....	20	.....	20
West Virginia	94	.....	120	.....	.....	.....	.....	.....	.....	214
Wisconsin	.....	108	160	.....	.....	.....	.....	.....	.....	268
	4,829	1,840	2,035	281	90	60	24	42	78	9,279

[a] Includes the Otto-Hoffmann and Schniewind types.

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By-product ovens at end of each year, 1914–1918.

State.	1914		1915		1916		1917		1918	
	Built.	Under construction.	Built.	Under construction.	Built.	Under construction.	Built.	Under construction.	Built.	Under construction.
Alabama	750	.....	750	.....	743	97	847	.....	847	324
Colorado	.....	.....	.....	.....	.....	120	.....	120	120	.....
Illinois	586	40	626	.....	626	.....	626	.....	626	88
Indiana	789	33	812	30	842	44	886	260	1,026	190
Kentucky	54	.....	54	54	108	.....	108	.....	108	.....
Maryland	120	.....	120	.....	120	240	120	240	180	180
Massachusetts	400	.....	400	.....	400	.....	400	.....	400	.....
Michigan	205	.....	205	24	229	40	269	.....	269	120
Minnesota	140	90	120	20	155	65	155	65	220	.....
Missouri	.....	56	56	.....	56	.....	56	.....	56	.....
New Jersey	150	.....	150	.....	150	110	260	55	260	55
New York	555	100	555	100	555	160	615	.....	615	60
Ohio	217	51	343	657	916	472	1,108	760	1,658	.....
Pennsylvania	1,522	262	1,744	212	1,956	700	1,956	700	2,368	638
Rhode Island	.....	.....	.....	.....	.....	.....	.....	.....	.....	40
Tennessee	.....	12	12	.....	12	.....	12	24	24	.....
Washington	5	.....	5	.....	5	.....	5	.....	20	.....
West Virginia	120	.....	120	94	214	.....	214	.....	214	120
Wisconsin	196	.....	196	.....	196	36	232	36	268	.....
	5,809	644	6,268	1,191	7,283	2,084	7,869	2,260	9,279	1,815

By-product ovens under construction in the United States at the end of 1917 and 1918.

1917.

State.	Koppers.	United-Otto.	Semet-Solvay.	Total.
Colorado	120	.....	.....	120
Indiana	140	.....	120	260
Maryland	240	.....	.....	240
Minnesota	65	.....	.....	65
New Jersey	55	.....	.....	55
Ohio	700	.....	60	760
Pennsylvania	700	.....	.....	700
Tennessee	.....	.....	24	24
Wisconsin	.....	36	.....	36
	2,020	36	204	2,260

1918.

State.	Koppers.	Semet-Solvay.	Wilputte.	Cambria.	Total
Alabama	204	120	.....	.....	324
Illinois	.....	.....	88	.....	88
Indiana	30	120	40	.....	190
Maryland	180	.....	.....	.....	180
Michigan	.....	120	.....	.....	120
New Jersey	55	.....	.....	.....	55
New York	.....	60	.....	.....	60
Pennsylvania	578	.....	.....	60	638
Rhode Island	40	.....	.....	.....	40
West Virginia	60	60	.....	.....	120
	1,147	480	128	60	1,815

CAPACITY OF BY-PRODUCT OVENS.

The capacity of a coke oven naturally depends on the number of hours adopted as standard coking time. Defined as "the maximum quantity of coke of the grade desired by the operator which can be

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produced when all conditions are favorable, with all ovens active," the maximum capacity of the by-product ovens in existence on January 1, 1918, was 27,000,000 net tons of coke a year. (See summary of weekly operating reports, p. 1459.) By the end of 1918 it had risen to 33,700,000 tons, an increase during the year of 25 per cent.

In actual practice, however, as the experience of the war period shows (see pp. 1458–1473), operation at 100 per cent of capacity can not be maintained over extended periods. Instead, an average operation of 85 per cent of maximum capacity or at the most 90 per cent appears to be the upper limit of probable performance. Applying these percentages to the maximum capacity of by-product ovens completed on December 31, 1918, gives the following results:

Probable maximum annual yield of by-product coke ovens completed on Dec. 31, 1918, in net tons.

	Coke.	Coal for charge.
90 per cent operation	30,300,000	42,500,000
85 per cent operation	28,600,000	40,200,000

The completion of ovens in course of construction on December 31, 1918, would increase the maximum capacity to a total of 42,100,000 tons of coke a year. The maximum yield to be expected in actual practice would then be:

Probable maximum annual yield of by-product ovens completed and under construction on Dec. 31, 1918, in net tons.

	Coke.	Coal for charge.
90 per cent operation	37,900,000	53,200,000
85 per cent operation	35,800,000	50,300,000

In other words, the end of the year 1918 found the country equipped with plants either built or in course of building capable of producing by-product coke at the rate of 36,000,000 to 38,000,000 tons, or say 37,000,000 tons, a year. It is significant to compare this figure with our annual requirements for coke, because the opinion is held by some in the coke trade that there is a limit to the profitable expansion of the by-product industry. It is reasoned that the construction of new by-product plants will be arrested when a total capacity is reached sufficient to supply the demand for coke in years when business is dull, leaving to the more elastic beehive industry the task of meeting the additional demand in years when business is active. Whatever may be the merit of this reasoning, it does not appear that the construction of by-product ovens had reached the saturation point at the end of 1918. Only twice in the last decade [1] has the production of coke fallen below 37,000,000 tons, the figure of capacity derived above for plants built and under construction on December 31, 1918. This quantity, 37,000,000 tons, is 66 per cent of the coke produced in

[1] In 1911 the output was 35,550,000 tons; in 1914 it was 34,560,000 tons.

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1918, the largest quantity ever used by the country in one year. It is 63 per cent of the coke required for producing 49,666,000 gross tons of pig iron, the annual capacity of the coke-burning blast furnaces completed or under construction on December 31, 1918, according to the annual statistical report of the American Iron and Steel Institute, the coke consumption being taken at 2,375 pounds per gross ton of iron. It is 62 per cent of the country's total requirements for coke in the war year 1918, as estimated by the United States Fuel Administration, less sales of gas-house coke, amounting to 1,814,000 tons.

BY-PRODUCT PLANTS.

A list of by-product coke plants, with notes regarding types of ovens, dates of installation, and uses of by-products, is given in the following table. Similar data for ovens under construction at the end of 1918 are given in another table. Although used primarily as a source of coke for iron-furnace operations and for the most part built by the iron-producing interests, a number of these plants have been installed with the main purpose of producing domestic gas for municipalities.

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By-product coke plants in the United States in 1918.

State.	Town.	Name of company owning plant.	Number of ovens.	Type of oven.	Year put in blast.[a]	Uses of coke.	Uses of surplus gas.	Benzol recovery plant.	Remarks.
Alabama	Alabama City	Gulf States Steel Co.	37	Koppers	1917	Blast furnace	Industrial fuel	Yes	
	Ensley	Tennessee Coal, Iron & R. R. Co.	240	Semet-Solvay	1898–1902	do	Boiler fuel	Yes	
	Fairfield	do	280	Koppers	1912	do	Industrial fuel	Yes	
	Tuscaloosa	Central Iron & Coal Co.	60	Semet-Solvay	1906–1914	Furnace, foundry, and heating.	Boiler fuel	Yes	Building 154 Koppers ovens additional.
	Woodward	Woodward Iron Co.	170	Koppers	1911–1914	Blast furnace	Industrial fuel	Yes	
	do	do	60	Wilputte	1917				
Colorado	Minnequa	Colorado Fuel & Iron Co.	120	Koppers	1918	do	do	Yes	Began July 5, 1918.
Illinois	Joliet	Coal Products Manufacturing Co.	18	Wilputte	1914	Furnace, foundry, and domestic.	Illuminating, domestic, and industrial fuel.	No	Gas sold to Western United Gas & Electric Co.
	do	do	35	Koppers	1912				
	do	Illinois Steel Co	280	do	1908–1909	Furnace	Industrial fuel	Yes	
	South Chicago	By-products Coke Corporation.	280	Semet-Solvay	1905–1915	Furnace, foundry, and domestic.	Illumination and boiler fuel.	Yes	
	Waukegan	North Shore Gas Co.	13	do	1912	Furnace	Illumination, household, and industrial fuel.	No	
Indiana	Gary	Illinois Steel Co	700	Koppers	1911–1918	Blast furnace and domestic.	Industrial fuel	Yes	
	Indiana Harbor	Inland Steel Co	130	do	1913–1917	do	Boiler fuel	Yes	
	Indianapolis	Citizens Gas Co	100	United-Otto	1909–1913	Furnace, foundry, and domestic.	Illumination and household uses.	Yes	Leased to Citizens Gas Co.
	do	Indianapolis Gas Co.	41	Semet-Solvay	1914				
	Linton	Linton Gas Co	3	Gas machinery	1917	Domestic	do	No	Built 1915, but not operated until 1917.
	Muncie	Central Indiana Gas Co.	22	Klönne	1912	do	do	Yes	Resumed operations February, 1919.
	Terre Haute	Indiana Coke & Gas Co.	30	Gas machinery	1916	Furnace, foundry, and domestic.	Illumination, domestic, and industrial fuel.	Yes	Building 30 Koppers ovens additional.
Kentucky	Ashland	Kentucky Solvay Coke Co.	108	Semet-Solvay	1913–1916	do	Boiler fuel	Yes	
Maryland	Sparrows Point	Bethlehem Steel Co.	180	Koppers	1914–1918	Blast furnace	Illumination and household use.	Yes	Originally 200 United-Otto ovens; torn down 1913 and Koppers ovens substituted. Erecting 180 Koppers additional.
Massachusetts	Everett	New England Fuel & Transportation Co.	400	United-Otto	1899	Foundry and domestic.	Illumination and household uses.	Yes	

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Michigan	Detroit	Solvay Process Co.	215	Semet-Solvay	1901–1917	Furnace, foundry, and domestic.	Illumination, household, and boiler fuel.	Yes.
	Wyandotte	Michigan Alkali Co.	54	Otto-Hoffman	1902–1916	Furnace and domestic.	Illuminating and household use.	No.
Minnesota	Duluth	Minnesota Steel Co.	90	Koppers	1915–1916	do	Industrial fuel	Yes.
	St. Paul	Minnesota By-Product Coke Co.	65	do	1918	Foundry and domestic.	Illuminating and household uses.	Yes.
	West Duluth	Zenith Furnace Co.	65	United-Otto	1904–1916	Furnace and domestic.	do	Yes.
Missouri	St. Louis	Laclede Gas Light Co.	56	Koppers	1915	Furnace, foundry, and domestic.	Illumination, domestic, and industrial fuel.	Yes.
New Jersey	Camden	Camden Coke Co.	150	Otto-Hoffmann	1903–1906	do	Illumination and fuel.	Yes.	First to install enrichment by benzol transfer.
	Kearny	Seaboard By-Product Coke Co.	110	Koppers	1917	do	Illumination and household uses.	Yes.	Constructing 55 Koppers additional.
New York	Buffalo	Wickwire Steel Co.	60	Semet-Solvay	1917	Blast furnace	Boiler fuel	Yes.	
	Geneva	Empire Coke Co.	46	do	1904–1909	Furnace, foundry, and domestic.	Illumination, household, and industrial uses.	Yes.	
	Lackawanna	Lackawanna Steel Co.	188	Otto-Hoffmann	1904	Furnace	Industrial fuel	Yes.	Constructing 60 Semet-Solvay additional.
	do	do	281	Rothberg					
	Solvay	Solvay Process Co.	40	Semet-Solvay	1893–1903	Foundry and domestic.	Boiler fuel	Yes.	First by-product plant in United States. Main purpose originally to obtain ammonia for alkali works.
Ohio	Canton	United Furnace Co.	47	Koppers	1916	Furnace and domestic.	Boiler fuel	Yes.	
	Cleveland	American Steel & Wire Co.	180	do	1918	Blast furnace	Illumination, household, and industrial uses.	Yes.	Began April, 1918.
	do	Cleveland Furnace Co.	100	Semet-Solvay	1910–1915	Furnace and domestic.	do	Yes.	49 of these originally 80 Rothberg ovens.
	do	McKinney Steel Co.	204	Koppers	1916	do	Industrial fuel	Yes.	No benzol recovery until 1917.
	Dover	Dover By-Products Coke Co.	24	Roberts flueless	1916	Furnace, foundry, and domestic.	do	Yes.	
	Hamilton	Hamilton-Otto Coke Co.	100	Otto-Hoffmann	1901–1909	Furnace and domestic.	Illumination, domestic and industrial fuel.	Yes.	Gas purchased and distributed by Hamilton Utilities Co.
	Ironton	Ironton Solvay Coke Co.	60	Semet-Solvay	1918	do	Industrial fuel	Yes.	Began August, 1918.
	Lorain	National Tube Co.	208	Koppers	1918	Blast furnace	do	Yes.	Do.
	Portsmouth	Portsmouth Solvay Coke Co.	108	Semet-Solvay	1917	Furnace and domestic.	do	Yes.	
	Toledo	Toledo Furnace Co.	94	Koppers	1916	Furnace, foundry, and domestic.	Illumination, domestic, and public utilities.	Yes.	

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By-product coke plants in the United States in 1918—Continued.

State.	Town.	Name of company owning plant.	Number of ovens.	Type of oven.	Year put in blast.[a]	Uses of coke.	Uses of surplus gas.	Benzol recovery plant.	Remarks.
Ohio—(Contd.).	Youngstown	Brier Hill Steel Co.	84	Koppers	1917	Furnace	Industrial fuel	Yes	
	....do	Republic Iron & Steel Co.	143	....do	1914–15	Furnace and domestic.	Steam and heating	Yes	
	....do	Youngstown Sheet & Tube Co.	306	....do	1916–1918	....do	Industrial fuel	Yes	
Pennsylvania	Chester	Philadelphia Suburban Gas & Electric Co.	40	Semet-Solvay	1904	Furnace	Illumination, domestic, and industrial fuel.	Yes	Coke-oven gas mixed with water gas before being sold.
	Clairton	Carnegie Steel Co.	640	Koppers	1918	Furnace and domestic.	Industrial use	Yes	Began June, 1918; constructing 128 Koppers additional.
	Farrell	....do	212	Otto-Hoffmann	1908	....do	....do	Yes	
	Dunbar	American Manganese Manufacturing Co.	110	Semet-Solvay	1896–1903	....do	Boiler fuel	Yes	
	Glassport	Allegheny By-Product Coke Co.	120	....do	1897	....do	....do	Yes	
	Johnstown	Cambria Steel Co.	92	Koppers	1915				
	....do	....do	27	Gas machinery	1914				Constructing 60 Cambria additional.
	....do	....do	343	United-Otto	1896–1907	....do	Fuel	Yes	
	....do	....do	90	Cambria	1918				
	South Bethlehem	Bethlehem Steel Co.	424	Koppers	1915–16	Furnace	....do	Yes	Originally 300 Didier ovens; replaced by Koppers ovens.
	Lebanon	....do	90	Semet-Solvay	1904	....do	....do	Yes	228 United-Otto ovens taken over from Lackawanna Steel Co. abandoned.
	Steelton	....do	120	....do	1907	....do	Illumination and fuel.	Yes	
	....do	....do	60	Koppers	1918				
Tennessee	Altonpark	Chattanooga Coke & Gas Co.	24	Semet-Solvay	1918	Furnace, foundry, and domestic.	Illumination, household, and industrial fuel.	Yes	12 Roberts ovens abandoned.
Washington	Seattle	Seattle Lighting Co.	20	Klönne	1914	Foundry and domestic.	Illumination, domestic and industrial fuel.	No	Gas mixed with other gases when sold; supplies Seattle and suburbs.
West Virginia	Benwood	National Tube Co.	120	Semet-Solvay	1896–1901	Furnace	Boiler fuel	Yes	
	Follansbee	La Belle Iron Works.	94	Koppers	1917	Blast furnace and domestic.	Industrial fuel	Yes	

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Wisconsin	Mayville	Northwestern Iron Co.	108	Otto-Hoffmann	1914–1917	Furnace and domestic.	Fuel	Yes	
	Milwaukee	Milwaukee Coke & Gas Co.*	160	Semet-Solvay	1904–1906	Furnace, foundry, and domestic.	Illumination and household use.	Yes	Gas sold to Milwaukee Gas Light Co.

* The first and last years are given for those plants that have two or more installations.

By-product ovens under construction in the United States on Jan. 1, 1919.

State.	Town.	Name of company owning plant.	Number of ovens.	Type of oven.	Benzol-recovery plant.	Remarks.
Alabama	Birmingham	Birmingham Coke & By-Product Co	50	Koppers		Construction suspended after armistice, but since resumed.
	do	Sloss-Sheffield Steel & Iron Co	120	Semet-Solvay		
	Fairfield	Tennessee Coal, Iron & R. R. Co	154	Koppers	Yes	Enlarging plant; 280 already in operation.
Illinois	South Chicago	International Harvester Co	88	Willputte		Will operate about Oct. 1, 1919.
Indiana	Indianapolis	Citizens Gas Co	40	do		Enlarging plant; already operating United-Otto and Semet-Solvay ovens.
	Indiana Harbor	By-Products Coke Corporation	120	Semet-Solvay	Yes	
	Terre Haute	Indiana Coke & Gas Co	30	Koppers	Yes	Enlarging plant; already operating gas machinery ovens.
Maryland	Sparrows Point	Bethlehem Steel Co	180	do	Yes	Enlarging plant; 180 already in operation.
Michigan	Detroit	Ford Motor Co	120	Semet-Solvay	Yes	Will operate early part of 1919.
New Jersey	Kearney	Seaboard By-Product Coke Co	55	Koppers	Yes	Enlarging plant; 110 already in operation.
New York	Lackawanna	Lackawanna Steel Co	60	Semet-Solvay	Yes	Enlarging plant; already operating Rothberg and United-Otto ovens.
Pennsylvania	Clairton	Carnegie Steel Co	128	Koppers	Yes	Enlarging plant; 640 already in operation.
	Johnstown	Cambria Steel Co	60	Cambria	Yes	Enlarging plant.
	Midland	Pittsburgh Crucible Steel Co	100	Koppers		Will operate about Nov. 1, 1919.
	Pittsburgh	Jones & Laughlin Steel Co	240	do	Yes	
	Swedeland	Rainey-Wood Coke Co	110	do		Will operate about Oct. 1, 1919.
Rhode Island	Providence	Providence Gas Co	40	do	No	Began Feb. 1, 1919.
West Virginia	Fairmont	Domestic Coke Corporation	60	do		
	Newburg	do	60	Semet-Solvay		

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VALUE OF COKE PRODUCED.

CHANGE IN SCHEDULES.

A change in the form of inquiry used, already referred to, renders it difficult to compare the value of coke in 1918 with that in earlier years. A considerable proportion of the coke produced in the United States is made in ovens or retorts operated by large corporations that not only mine the coal and make the coke but also operate blast furnaces and steel mills which consume the entire product of the ovens. Under such conditions the fixing of a value upon the coke and upon the coal consumed in making it is purely arbitrary. By some corporations the coke is charged to the furnace department at cost; by others a percentage of profit is added or the reported value is based on what the coke would cost if purchased.

Formerly each operator was asked to estimate the value of the coke produced but not sold, but for some years prior to 1918 it had been apparent that the figures thus obtained were of questionable accuracy, the more so as the substitution of by-product for beehive ovens steadily increased the proportion of the total quantity for which only estimated values were possible. These considerations led to a change in the statistical schedule in 1918. Copies of the 1918 schedules are reprinted on page 1524. Instead of requesting the operator to estimate the value of the coke used but not sold, the schedule asked separately for the production, the quantity sold, and the value of the quantity sold, all of which could be accurately measured. The result of the 1918 inquiry is shown in detail in the first of the accompanying tables.

GENERAL STATISTICS.

Of the 56,478,000 tons of merchantable coke produced in all types of ovens, about 40 per cent was not sold but used by the producer, the great bulk of this being undoubtedly blast-furnace coke.[1] A total of 33,973,000 tons was sold, of which 27,364,000 tons was furnace coke, 3,861,000 tons foundry coke, and 2,748,000 tons domestic and other coke. The proportion used by the producers was naturally much greater for by-product coke than for beehive coke. Two-thirds of the by-product coke was consumed by the companies that produced it. The total sales of by-product coke amounted to 8,316,000 tons, valued at $65,548,000. Of the beehive coke produced, on the other hand, only one-sixth was consumed by the producing companies. The total quantity so consumed was 4,885,000 tons. Alabama, Colorado, Ohio, and parts of Tennessee and southwestern Virginia are the only localities where the proportion of the output consumed by the producers is large.

Interest attaches to the relative proportions of the sales for furnace, foundry, and domestic use. The sales of furnace coke constituted 90 per cent of the total quantity marketed by beehive operators but only 50 per cent of the by-product coke. Foundry coke constituted 9 per cent of the quantity marketed from beehive ovens and 20 per cent of the by-product coke, and the total sales of by-product foundry coke were within 600,000 tons of the sales of

[1] The figures of sales and the quantity used by producer are almost invariably exclusive of breeze.

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beehive foundry coke. Sales of beehive coke for domestic purposes constituted 1 per cent of the total beehive coke sold, while sales of domestic by-product coke amounted to 2,537,000 tons, 12 times as much as the domestic beehive coke, and formed 30 per cent of the total sales of by-product coke.

In the second of the following tables is given the average price realized per ton f. o. b. ovens on each grade of coke sold in each State. The figures are obtained by dividing the total receipts by the number of tons sold. It will be noted that the values of retort coke range consistently higher than those of beehive coke. As explained in previous reports, this is due not to the superior quality of by-product coke but to the fact that the retort ovens are installed at or near the centers of consumption, where markets for the gas and other by-products as well as for the coke are available, but at considerable distances from the coal mines. Hence the expenses of transportation are borne by the coal and are added to the value of the coal as charged into the ovens, and an equivalent value is necessarily added to the coke. The beehive and similar types of ovens, on the other hand, are in the immediate vicinity of the mines, and the expenses of transportation are borne by the coke; the beehive coke thus costs the ultimate consumer as much as the apparently higher-valued retort coke.

Throughout the year 1918 maximum prices on coke fixed by the Fuel Administration under the Lever Act were in force. The theory underlying the prices was that the price of coke should bear a reasonable relation to prices of iron and steel products fixed by the War Industries Board and agreed to by the steel makers. A base price for furnace coke of $6 a net ton f. o. b. ovens in the Connellsville region was in effect throughout the year. A differential of $1 a ton was allowed for foundry coke, the Connellsville base being $7. In fixing maximum prices for by-product coke regard was had for the normal relation of the by-product price to the Connellsville region price. Normally the sales price of by-product coke is calculated on the basis of the prevailing Connellsville price plus freight charges from Connellsville to the point of consumption minus freight charges from the by-product coke plant to the consumer. For a discussion of coke prices during 1918 the reader is referred to the chapter on prices of coal and coke, 1913–1918, contained in this volume, pages 15–115, and to Part I of the report of the distribution division of the United States Fuel Administration, pages 88–90. The orders fixing prices on coke are to be found in "General orders, regulations, and rulings of the United States Fuel Administration."

In comparing the average realization figures shown in the accompanying table with the Government maximum prices, it is to be remembered that shipments on bona fide contracts entered into prior to September 22, 1917, were not affected by the Government prices. Many sales during 1918 were therefore consummated at prices below or above the maxima fixed by the Fuel Administrator.

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Beehive and by-product coke produced and sold or used by the producer in the United States, 1918, by States and kinds.

	Production.		Sales.						Used by producer (net tons).
	Coke (net tons).	Screenings or breeze (net tons).	Furnace.		Foundry.		Domestic and other.		
			Quantity (net tons).	Value.	Quantity (net tons).	Value.	Quantity (net tons).	Value.	
Alabama:									
Beehive	1,717,721	100	107,753	$671,367	153,749	$1,475,728	37,710	$278,559	1,412,617
By-product	2,634,451	217,349	109,417	663,586	10,503	58,659	48,333	242,769	2,453,468
	4,352,172	217,449	217,170	1,335,173	163,252	1,534,387	86,043	521,319	3,866,080
Colorado:									
Beehive	758,784	3,629	137,657	1,051,896	37,194	279,448	1,954	77,695	581,044
By-product	230,663	9,701	.....	.....	.....	.....	9,701		230,663
	989,447	13,330	137,657	1,051,896	37,194	279,448	11,655	77,695	811,707
Georgia:									
Beehive	22,048	.....	.....	.....	22,048	193,307	.....	.....	.....
Illinois:									
By-product	2,285,610	187,698	525,532	4,376,183	247,520	2,162,760	298,674	2,194,149	1,236,571
Indiana:									
By-product	3,898,215	290,175	28,377	259,155	187,493	1,862,230	293,992	1,993,825	3,502,061
Kentucky:									
Beehive	301,096	924	276,940	1,648,843	55	292	23,664	146,979	.....
By-product	517,749	16,320	334,467	1,411,586	103,956	714,036	78,596	528,078	.....
	818,785	17,244	611,407	3,060,434	104,011	714,328	102,262	675,057	.....
Maryland:									
By-product	474,368	46,336	4,957	48,434	.....	.....	.....	.....	458,256
Massachusetts:									
By-product	556,397	.....	.....	.....	263,713	(a)	269,754	(a)	.....
Michigan:									
By-product	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Minnesota:									
By-product	784,065	38,054	54,178	371,867	28,714	231,877	249,737	2,260,247	433,747
Missouri:									
By-product	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
New Jersey:									
By-product	682,148	74,725	458,013	(a)	69,794	(a)	162,336	(a)	54,869
New Mexico:									
Beehive	597,072	2,120	596,496	3,725,769	.....	.....	76	608	.....
New York:									
By-product	1,069,567	58,362	360,914	3,304,432	8,137	91,063	76,401	736,052	617,743

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Ohio:									
Beehive	138,909	.....	.....	.....	6,850	340,029	.....	.....	137,269
By-product	5,226,334	505,438	946,763	6,795,533	36,496		195,150	950,358	3,952,163
	5,365,243	505,438	946,763	6,795,533	43,346	340,029	195,150	950,358	4,089,432
Oklahoma:									
Beehive	(a)	.....	(a)	(a)	.....	.....	.....	.....	.....
Pennsylvania:									
Beehive	22,136,664	106,551	18,823,133	109,419,074	1,344,748	9,673,491	78,153	489,599	1,930,364
By-product	4,586,931	327,177	562,034	3,770,419	.....	.....	100,148	505,064	3,935,199
	26,723,645	433,728	19,385,167	113,189,493	1,344,748	9,673,491	178,301	994,663	5,865,563
Tennessee:									
Beehive	302,637	2,268	105,301	749,372	736	6,195	.....	.....	196,835
By-product	124,469	.....	108,335	872,969	13,739	127,827	1,412	11,189	.....
	427,106	2,268	213,636	1,622,341	14,475	134,022	1,412	11,189	196,835
Utah:									
Beehive	(a)	.....	(a)	(a)	(a)	(a)	(a)	(a)	.....
Virginia:									
Beehive	1,234,256	4,228	595,967	3,664,201	202,547	1,540,489	4,228	28,619	435,637
Washington:									
Beehive	93,659	.....	75,505	691,532	18,334	220,705	27	202	.....
By-product	30,129	5,314	.....	.....	3,563	33,849	15,416	146,453	10,132
	123,788	5,314	75,505	691,532	21,897	254,554	15,443	146,655	10,132
West Virginia:									
Beehive	2,716,613	4,322	2,045,779	12,691,751	426,590	3,220,375	54,843	295,204	191,522
By-product	603,393	36,179	72,378	570,426	.....	.....	12,090	91,888	517,763
	3,320,006	40,501	2,118,157	13,262,177	426,590	3,220,375	66,933	387,092	709,285
Wisconsin.									
By-product	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Combined States:									
Beehive	461,393	.....	452,097	3,468,278	18,305	139,672	9,856	73,595	.....
By-product	2,293,021	191,542	582,324	8,347,656	662,424	10,279,129	725,357	9,196,509	322,716
	2,754,414	191,542	1,034,421	11,815,934	680,729	10,418,801	735,213	9,269,104	322,716
Total beehive	30,480,792	124,142	23,216,627	137,784,308	2,230,156	16,802,144	210,511	1,319,053	4,885,318
Total by-product	25,997,580	1,999,370	4,147,695	30,792,247	1,631,052	15,849,017	2,537,059	18,907,079	17,753,348
Grand total	56,478,372	2,123,512	27,364,322	168,574,555	3,861,208	32,651,161	2,747,570	20,226,132	22,638,666

(a) Included under "Combined States."

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Average price per ton realized for coke sold in 1918.

State.	Beehive.				By-product.			
	Furnace.	Foundry.	Domestic.	Average, all grades.	Furnace.	Foundry.	Domestic.	Average, all grades.
Alabama	$6.23	$9.66	$7.39	$8.14	$6.06	$5.58	$5.02	$5.74
Colorado	7.64	7.51	2.91	7.56	.....	.....	7.42	7.42
Georgia	.....	8.77	.....	8.77	.....	.....	.....	.....
Illinois	.....	.....	.....	.....	8.33	8.74	7.35	8.15
Indiana	.....	.....	.....	.....	9.13	9.93	6.78	8.07
Kentucky	5.95	5.31	6.21	5.97	4.22	6.87	6.72	5.13
Minnesota	.....	.....	.....	.....	6.86	9.78	8.97	8.68
New Mexico	6.25	.....	8.00	6.25	.....	.....	.....	.....
New York	.....	.....	.....	.....	9.16	11.19	9.63	9.28
Ohio	.....	.....	.....	.....	7.18	7.88	4.87	6.82
Pennsylvania	5.81	7.19	6.26	5.91	6.71	.....	5.04	6.46
Tennessee	7.12	8.42	.....	7.13	8.06	9.30	7.92	8.20
Virginia	6.15	7.61	6.77	6.52	.....	.....	.....	.....
Washington	9.16	12.04	7.48	9.72	.....	9.50	9.50	9.50
West Virginia	6.20	7.55	5.38	6.41	7.88	.....	7.60	7.84
	5.93	7.53	6.27	6.21	7.42	9.72	7.45	7.42

In order to maintain the continuity of the Survey's statistical record of coke, an estimated figure of total value at the oven of all coke produced has been prepared. Assigning a value to the coke consumed by the producer comparable to the average realized price on the coke actually sold gives an approximate figure of $382,000,000. In comparison with the total for 1917 this was an increase of $84,000,000, or 28 per cent. Beehive coke increased in total value 18 per cent, rising from $160,000,000 to $189,000,000. The value of by-product coke increased even more sharply. The 1917 output was valued at $139,000,000. For 1918 it is placed at $193,000,000, an increase of 39 per cent. The greater increase in the value of by-product coke was attributable largely to the increase in quantity produced, for the average value per ton rose only $1.24 as compared with $1.40 for beehive coke. The average realized price for all beehive coke was $6.21, for by-product coke $7.42. The weighted average for both types was $6.77.

Average prices realized for beehive and by-product coke, 1908–1918, per net ton.

Year.	Beehive.	By-product.	Mean average.	Year.	Beehive.	By-product.	Mean average.
1908	$2.20	$3.44	$2.40	1914	$2.15	$3.39	$2.56
1909	2.10	3.27	2.29	1915	2.07	3.45	2.54
1910	2.17	3.47	2.39	1916	2.69	3.95	3.13
1911	2.05	3.48	2.37	1917	4.81	6.18	5.36
1912	2.10	3.84	2.54	1918	6.21	7.42	6.77
1913	2.39	3.82	2.78				

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Average realized price per net ton, at the ovens, of the coke made in the United States, 1914–1918.

State.	1914	1915	1916	1917	1918 [b]
Alabama	$2.73	$2.78	$3.49	$5.80	$6.68
Colorado	3.30	3.34	3.55	4.98	7.53
Georgia	4.10	4.05	4.94	8.14	8.77
Illinois	4.11	4.16	4.58	6.31	8.15
Indiana	3.98	4.19	4.61	6.17	8.07
Kentucky	2.19	2.15	2.77	4.77	5.44
Maryland	[a]	2.43	2.83	7.57	[a]
Minnesota	[a]	3.72	4.56	7.07	8.68
New Jersey	2.67	[a]	[a]	[a]	[a]
New Mexico	3.39	3.25	3.42	4.86	6.25
New York	3.77	3.72	3.91	6.94	9.28
Ohio	3.21	3.12	3.82	6.35	6.84
Pennsylvania	2.10	2.06	2.71	4.86	6.00
Tennessee	2.43	2.62	2.78	4.94	7.44
Virginia	2.02	1.97	2.43	4.44	6.52
Washington	5.56	5.13	5.27	7.38	9.67
West Virginia	1.99	1.98	2.61	4.99	6.67
Combined States	3.79	3.75	4.05	6.43	8.58
Average	2.56	2.54	3.13	5.36	6.77

[a] Included under "Combined States." [b] Values estimated on basis of sales.

PRICES IN CONNELLSVILLE REGION.

The most active coke market in the United States is the Connellsville district of Pennsylvania, and as the prices for the coke from that district govern largely those in other places, the following table is given showing Connellsville prices, by months, during the years 1915, 1916, 1917, and 1918. These prices are the quotations for Connellsville coke at the ovens given in the current issues of the Iron Age. The spot prices are those quoted for immediate delivery, and the contract prices, as the term implies, are those established to cover the requirements of the buyer for a specified period, usually for six months. The relation of supply to demand governs to a large extent, of course, the range of prices for both spot and contract coke. When demand is strong and a shortage of supplies is felt, as in the early months of 1913, the prices for spot coke were above contract prices. Normally the greater part of the coke of this region changes hands on the contract basis.

In 1916 prices per ton for both furnace and foundry coke were more than three times the top quotations for 1915 and were more than twice the previous maximum of 1913. This upward swing of prices continued in 1917, spot furnace coke reaching a maximum quotation of $16 in July and spot foundry coke a maximum quotation of $14 in March and again in July and August. On September 22 a presidential order was issued, effective September 24, establishing $6 a net ton as a maximum price for both grades of coke, and a subsequent order of the Fuel Administrator, effective November 10, 1917, set maximum prices of $6 a net ton f. o. b. for furnace coke and $7 a ton for foundry coke.

The Connellsville Courier is authority for the statement that prices realized from sales of spot coke in August, 1917, averaged for the region $13.42 a ton for furnace coke and $14.25 for foundry coke—a record for the region; and, according to the reports received by the Geological Survey, the average prices realized for the Connellsville and Lower Connellsville districts were, respectively, $3.95 and $4.85 a ton in 1917, compared with $2.42 and $2.60 a ton in 1916, increases of 63 and 87 per cent.

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Throughout 1918 the Fuel Administration prices of $6 a net ton f. o. b. ovens for furnace coke and $7 a ton for foundry coke were continued in force.

The average realized prices in 1918, reported to the Geological Survey by operators in the Connellsville region, were $5.80 for furnace coke and $7.20 for foundry coke. That these averages should not agree exactly with the Government price was to be expected, inasmuch as considerable quantities of coke continued to move at prices fixed by bona fide contracts negotiated before the issuance of the original price order.

For a historical review of prices during the war the reader is referred to the chapter on "Prices of coal and coke, 1913–1918," pages 15–115.

Prices of Connellsville furnace and foundry coke per net ton at the ovens, 1915, 1916, 1917, and 1918.

Furnace.

Month.	1915		1916		1917		1918, Government maximum.
	Spot.	Contract.	Spot.	Contract.	Spot.	Contract.	
January	$1.50–$1.60	$1.65–$1.75	$2.75–$3.50	$2.50–$2.75	$8.50–$9.50	$6.00–$7.00	$6.00
February	1.50– 1.60	1.65– 1.75	2.75– 4.00	2.50– 4.00	8.00–11.50	6.00– 7.00	6.00
March	1.50– 1.60	1.65– 1.75	3.25– 3.75	2.75– 3.00	8.00–12.00	.....	6.00
April	1.50– 1.60	1.65– 1.75	2.00– 3.00	2.40– 3.00	7.00– 8.50	8.00	6.00
May	1.50– 1.60	1.65– 1.75	2.00– 3.00	2.50– 3.50	7.00– 9.00	8.00	6.00
June	1.50– 1.60	1.65– 1.75	2.30– 2.60	2.35– 2.75	10.00–13.00	9.00– 9.50	6.00
July	1.55– 1.75	1.70– 1.85	2.50– 2.75	2.35– 2.65	11.00–16.00	.....	6.00
August	1.50– 1.60	1.75– 1.85	2.50– 3.00	2.35– 2.60	10.00–15.00	.....	6.00
September	1.50– 1.75	1.75– 1.85	2.85– 3.10	2.50– 3.00	6.00–13.50	6.00– 9.00	6.00
October	1.75– 2.00	2.25– 2.40	3.25– 7.50	3.00– 4.00	6.00	6.00	6.00
November	2.10– 2.50	2.25– 2.50	6.50– 8.00	3.75– 4.00	6.00	6.00	6.00
December	2.10– 3.50	2.40– 2.50	7.00–10.00	4.00– 5.00	6.00	6.00	6.00

Foundry.

January	$2.00	$2.15–$2.25	$3.50–$3.75	$3.25–$3.50	$10.00	$7.00–$8.00	$7.00
February	2.00	2.15– 2.50	3.50– 3.75	3.25– 3.50	$10.00–12.00	7.00– 9.00	7.00
March	2.00	2.15– 2.50	3.75– 4.00	3.50– 3.75	10.00–14.00	7.00– 8.00	7.00
April	$2.00– 2.25	2.15– 2.30	3.00– 4.00	3.25– 3.75	8.50–10.00	9.00	7.00
May	1.90– 2.25	2.15– 2.50	2.75– 3.25	3.25– 3.50	8.50–10.00	8.50– 9.50	7.00
June	1.90– 2.25	2.15– 2.50	2.75– 3.25	3.25– 3.50	10.50–13.00	10.00–11.00	7.00
July	2.00– 2.25	2.25– 2.50	2.75– 3.25	3.00– 3.50	13.00–14.00	10.00	7.00
August	2.00– 2.25	2.25– 2.50	3.00– 3.50	3.25– 3.75	11.50–14.00	12.50	7.00
September	2.00– 2.25	2.25– 2.50	3.25– 3.50	3.50– 3.75	6.00	6.00	7.00
October	2.15– 2.75	2.40– 2.75	3.25– 6.00	3.75– 4.50	6.00	6.00	7.00
November	2.75– 3.00	2.60– 3.25	6.00– 8.00	4.00– 6.00	6.00	6.00	7.00
December	2.75– 3.50	3.00– 3.25	7.50–10.00	5.00– 7.00	7.00	7.00	7.00

COAL USED IN THE MANUFACTURE OF COKE.

GENERAL STATISTICS.

The quantity of coal consumed in making coke reported in this chapter each year is at considerable variance with the quantity reported as made into coke in the chapter on the production of coal. The reason for this discrepancy is that in the chapter on coal the figures for the quantity made into coke take into account only the coal which is coked at the mines. The coal shipped to ovens at a distance, which includes nearly all the coal charged into by-product ovens reported by the coke manufacturers, is included by the coal operators in their shipments and not in the quantity they report as made into coke.

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As a consumer of soft coal the coke industry ranks next to the railroads and the group of general industrial plants. In 1917 and again in 1918 about 15 per cent of the bituminous coal produced was consumed in the manufacture of coke.

The total quantity of coal consumed in making coke in 1918 was 85,028,000 tons, of which 48,160,000 tons, or 56.6 per cent, was used in beehive ovens and 36,868,000 tons in by-product ovens. In comparison with the figures for 1917 this was an increase in total consumption of 1,276,000 tons, or 1.5 per cent. The cost of the coal used showed a much greater increase, rising from $221,309,000 to $267,312,000. The average cost of the coal per ton laid down at the oven was $3.14 in 1918, as against $2.64 in 1917. Not all of this figure represented revenue to the producer of the coal, however, for in the case of most by-product plants it includes the freight rate from the mine to the place of use.

The average quantity of coal used per ton of coke produced in 1918 was 1.505 tons, a slight decrease as compared with the average in 1917. Like many other averages, however, this figure is capable of misinterpretation; the decline in average coal consumption indicated was not due to improved performance in either beehive or by-product practice (see pp. 1505–1506), but rather to the progress in substituting by-product for beehive coke, the former requiring less coal than the latter. The average consumption of coal per ton of coke increased in 1918 in both branches of the industry.

In the fifth column of the acompanying table is shown the average cost of the coal used per ton of coke, obtained by multiplying together the figures in the third and fourth columns. It is significant to note not only the rising cost of the coal per ton of coke but also the great variation in cost in different localities. The average cost for the whole country in 1918 was $4.73 a ton. The lowest coal cost was $3.35 at the beehive plants of New Mexico; the highest $9.07 for the State of Washington.

The high coal costs in the States where by-product coke is made are due to the freight charges involved in transporting the coal from mine to oven. Among the larger producers Pennsylvania, though containing many by-product ovens, was easily lowest in point of coal costs, with an average of $3.72.

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Coal used in the manufacture of coke in the United States in 1917 and 1918.

State.	Coal used (net tons).	Total cost of coal.	Average cost of coal per ton.	Quantity of coal per ton of coke (net tons).	Cost of coal to a ton of coke.
1917.					
Alabama	7,638,841	$18,776,218	$2.46	1.561	$3.840
Colorado	1,784,631	4,232,780	2.37	1.604	3.801
Georgia	72,689	180,358	2.48	1.836	4.553
Illinois	3,233,669	12,310,776	3.81	1.412	5.380
Indiana	4,817,942	18,626,179	3.87	1.361	5.267
Kentucky	1,341,788	3,005,665	2.24	1.555	3.483
Maryland	733,184	3,707,132	5.06	1.413	7.150
Minnesota	676,881	2,710,955	4.01	1.381	5.538
New Mexico	936,411	1,373,262	1.47	1.621	2.383
New York	1,401,458	6,061,526	4.33	1.411	6.110
Ohio	5,365,998	23,457,589	4.37	1.453	6.350
Pennsylvania	42,319,784	93,275,898	2.20	1.516	3.335
Tennessee	759,634	1,286,095	1.69	1.847	3.121
Utah and Washington	876,067	1,941,199	2.22	1.761	3.909
Virginia	2,093,943	3,484,193	1.66	1.686	2.866
West Virginia	5,482,094	9,785,358	1.78	1.687	3.003
Combined States	4,226,357	17,093,680	4.04	1.355	5.474
	83,752,371	221,308,858	2.64	1.509	3.984
1918.					
Alabama	6,827,626	$20,947,917	$3.07	1.569	$4.817
Colorado	1,562,031	5,264,314	3.37	1.579	5.321
Georgia	38,280	133,496	3.49	1.736	6.059
Illinois	3,199,020	14,800,703	4.63	1.400	6.482
Indiana	5,318,908	23,953,483	4.50	1.364	6.138
Kentucky	1,256,459	3,973,203	3.16	1.535	4.851
Maryland	696,576	3,891,990	5.59	1.468	8.206
Minnesota	1,069,775	5,680,317	5.31	1.364	7.243
New Mexico	1,047,675	1,998,513	1.91	1.755	3.352
New York	1,516,580	6,764,085	4.46	1.413	6.304
Ohio	7,998,823	31,881,303	3.99	1.491	5.949
Pennsylvania	40,573,894	99,520,344	2.45	1.518	3.719
Tennessee	731,077	2,025,398	2.77	1.712	4.742
Virginia	2,042,429	4,978,092	2.44	1.655	4.038
Washington	201,870	1,122,092	5.56	1.631	9.068
West Virginia	5,369,792	13,410,043	2.50	1.617	4.043
Combined States:					
Oklahoma and Utah	814,707	2,080,726	2.55	1.766	4.503
Massachusetts, Michigan, Missouri, New Jersey, and Wisconsin	4,761,904	24,884,694	5.23	1.348	7.050
	85,028,018	267,311,815	3.14	1.505	4.726

COAL FOR BY-PRODUCT COKE.

The quantity of coal consumed in the manufacture of by-product coke in 1918 is shown in the following table, with comparable statistics for the 10 years preceding. Most of the by-product plants are in the iron-producing centers and are at a considerable distance from the coal fields; in fact, by-product coke was made in five States in 1918 in which there are no coal deposits and in six others in which no high-grade coking coal is found. It is the usual practice to use a mixture of coals in by-product ovens, and a favorite combination seems to be a high-volatile or "gas" coal from eastern Kentucky, from the Kanawha or Fairmont district of West Virginia, or from southwestern Pennsylvania, with low-volatile or "smokeless" coal from the Pocahontas and New River fields of West Virginia or from central Pennsylvania. It thus happens that a large part of the coal used comes from the mines in West Virginia, and West Virginia coal is used at places as far distant as Illinois, Indiana, Wisconsin, and Minnesota.

The origin of the coal used in 1917 by the by-product plants in each State is given in the second of the following tables. Comparable statistics for 1918 are not available.

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Coal used in the manufacture of by-product coke in the United States, 1908–1918, in net tons.

State.	1908	1909	1910	1911	1912	1913	1914	1915	1916	1917	1918
Alabama	685,354	776,319	769,212	928,255	1,873,581	2,832,282	2,909,348	2,987,710	3,635,663	3,980,243	3,877,634
Colorado											345,377
Illinois	500,400	1,681,498	1,971,396	2,067,870	2,317,307	2,481,198	1,962,132	2,335,933	3,182,650	3,233,669	3,199,620
Indiana			107,402	1,137,257	3,198,874	3,535,136	3,125,207	3,685,774	4,626,204	4,817,942	5,318,900
Kentucky						98,846	280,456	337,679	614,922	742,162	723,113
Maryland	375,515	464,788	511,622	518,738	462,998	372,005	129,891	470,326	749,936	733,184	696,576
Massachusetts	594,095	572,142	581,955	616,614	677,793	696,679	707,718	666,930	728,256	738,873	676,866
Michigan	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Minnesota	(a)	(a)	(a)	(a)	(a)	(a)	(a)	180,767	573,371	676,881	1,099,775
Missouri								(a)	(a)	(a)	(a)
New Jersey	344,124	336,336	328,722	335,166	462,998	339,351	328,921	349,976	343,513	621,699	994,300
New York	664,121	727,569	910,293	955,067	1,095,198	1,067,207	659,418	975,656	1,098,249	1,401,458	1,516,580
Ohio	102,332	123,471	227,327	285,836	337,987	327,604	643,169	956,656	2,447,812	5,141,046	7,775,023
Pennsylvania	1,483,762	2,422,239	2,696,645	1,969,950	2,676,751,	3,492,227	2,964,559	4,301,726	5,650,352	5,716,221	6,514,868
Tennessee								32,084	68,451	63,793	166,157
Washington							(a)	(a)	45,756	45,025	47,410
West Virginia		125,656	114,779	221,609	252,849	192,270	64,314	202,762	276,481	727,778	853,684
Wisconsin	519,617	593,931	672,707	770,839	831,984	847,469	(a)	(a)	(a)	(a)	(a)
Combined States	429,288	572,185	686,992	619,383	579,223	813,005	1,754,888	2,070,403	2,482,866	2,865,785	3,090,738
	5,699,058	8,390,129	9,529,042	10,446,584	14,767,543	17,095,369	15,500,021	19,554,382	26,524,502	31,505,759	36,867,721

a Included under "Combined States."

Source of coal used in the manufacture of by-product coke in 1917.

State in which coke was made.	Alabama.	Illinois.	Indiana.	Kentucky.	Ohio.	Pennsylvania.	Tennessee.	Virginia.	Washington.	West Virginia.	Foreign.	Total.
Alabama	3,980,243											3,980,243
Illinois		330,604		634,096		34,579		8,171		2,226,219		3,233,669
Indiana		104,559	448,631	1,131,277		307,229		83,328		2,652,918		4,817,942
Kentucky				284,990						457,172		742,162
Maryland						183,286				549,898		733,184
Massachusetts				13,148				116,322		454,793	154,610	738,873
Minnesota						222,711				444,170		676,881
New Jersey						278,585				343,114		621,699
New York						1,283,264				118,194		1,401,458
Ohio				1,700,372	61,136	2,106,629				1,272,909		5,141,046
Pennsylvania						5,563,609				152,612		5,716,221
Tennessee							63,793					63,793
Washington									45,025			45,025
West Virginia						552,695				175,083		727,778
Michigan												
Missouri		10,351		482,371		396,556	16,960			1,969,547		2,865,785
Wisconsin												
	3,980,243	445,514	448,631	4,246,254	61,136	11,019,153	80,753	207,821	45,025	10,816,619	154,610	31,505,759

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The extension of by-product coking has intensified the demand for both the low-volatile and high-volatile coals used in the mixture charged into the ovens. Aside from deposits in the Southwest and the Rocky Mountains, which are geographically inaccessible to most of the by-product plants, the deposits of low-volatile coal in the United States are confined to the belt of semibituminous coals which extends, with some interruptions, along the eastern margin of the great Appalachian coal basin from the Snowshoe district of Pennsylvania to southern West Virginia. These coals, known to the trade as smokeless, were already much prized for domestic use and for raising steam, particularly under ships' boilers. They were much in demand for export, partly because they lie nearest the coast, partly because alone among American coals they compare favorably with the best British and German coals. The provision of the necessary low-volatile coals for by-product ovens was therefore a continuing problem during the war period, especially as they must be transported long distances to reach the by-product plants in Indiana, Illinois, Michigan, and Minnesota.

No less difficult was the problem of securing the high-volatile constituent of the by-product mix. The type of coal desired for this purpose, besides possessing the coking quality, is high in the volatile constituents from which the by-products are derived and low in ash and sulphur. This type of coal is best developed in the East near the western limb of the Appalachian coal basin, notably in western Pennsylvania, parts of southern West Virginia, and eastern Kentucky. Coals meeting these requirements are also in demand for the manufacture of coal gas and for use as "gas" coal in open-hearth furnaces. To meet the growing demand for gas and by-product coals, extensive developments have been made, particularly in eastern Kentucky, where the growth in mine capacity has taxed to the limit the ability of the railroads to transport the product.

So acute was the problem of the supply of coal for by-product ovens that a special inventory of sources of supply was undertaken by the United States Fuel Administration. The following table presents the results of tabulating the production in 1917 of mines listed as producing coal suitable for the manufacture of by-product coke. The tabulation indicates that in 1917 these mines produced 122,000,000 tons of high-volatile by-product coal and 55,000,000 tons of low-volatile coal suitable for coke manufacture, a total of 177,000,000 tons. Of this total, only a sixth—31,506,000 tons—was carbonized in by-product ovens in 1917. It will be noted that the inventory was limited to districts east of the Mississippi. By-product coal, both high and low volatile, is produced west of that river, but the quantity has not been ascertained. Furthermore, it should be remembered that recent experiments have shown that coke suitable for some purposes can be made in the by-product oven from coals hitherto considered unfit for by-product use, such as those of Indiana and Illinois, and developments along this line would, of course, make available large quantities of coal produced in other localities than those listed below. The list of mines was determined by a committee of the Fuel Administration staff familiar with by-product coke-oven practice, after correspondence with all the operators of by-product ovens and many producers of coal. The classification as between first and second grade was not made in accordance with exact stand-

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ards or hard and fast rules, but was determined largely by the experience of users verified by the analyses of the coals. The following notes describe briefly the standards used in the classification: [1]

Answering your inquiry [of November 21, 1918], we have no exact standard by which coal is arbitrarily classified in the three different grades.

In order to be classed in the first grade the ash should not exceed 8 per cent as a maximum and the sulphur should not exceed 1 per cent in the coke. This allows for a considerable variation of sulphur in coal, as a much larger percentage will burn off in coking in some coals than in others.

Medium grade should analyze not more than 10 per cent in ash and coke made from this coal should not exceed 1.20 [per cent] in sulphur.

Any coals that are higher in sulphur or ash than second grade we have classed in the third grade and these coals we consider unsuitable for by-product use.

In addition to the analysis there is also a physical structure of the coke to be considered, and even though the analysis would class a coal as first grade, if it did not make coke of good structure, we would place this coal in a lower grade.

Bituminous coal suitable for use in the manufacture of by-product coke produced in 1917, in net tons.

Producing district.	Production of all kinds of bituminous coal.	Production of mines listed by the Fuel Administration as producing bituminous coal suitable for the manufacture of by-product coke.					
		High volatile.			Low volatile.		
		First grade.	Second grade.	Total.	First grade.	Second grade.	Total.
Central Pennsylvania.	59,044,092	1,715,722	3,613,062	5,328,784	7,356,720	3,360,815	10,717,535
Northern Pennsylvania	7,381,328	670,738	919,988	1,590,726	371,716	74,131	445,847
Western Pennsylvania [a]	102,063,891	58,957,980	8,775,461	67,733,441			
Somerset, Md.	13,843,238	92,612	33,618	126,230	2,941,750	2,951,381	5,893,131
Fairmont, W. Va.	17,567,575	6,644,914	1,884,211	8,529,125			
Northeastern Kentucky	6,453,679	5,389,454	196,713	5,586,167			
Hasard	1,853,353	878,009	92,902	970,911			
Logan	8,784,270	3,553,774	1,427,952	4,981,726			
Coal and coke—K. & M.	5,091,152	2,084,645	389,886	2,474,531			
Kanawha	7,656,440	3,409,895	773,277	4,183,172	116,999		116,999
Kenova-Thacker	6,332,261	2,119,580	1,238,985	3,358,565			
New River	15,096,036	283,994	599,776	883,770	9,360,542	4,401,930	13,762,472
Pocahontas and Tug River	24,947,362				22,055,212	1,689,788	23,745,000
Southwestern Virginia.	8,604,318	3,730,468	2,097,900	5,828,368	316,826		316,826
Southeastern Kentucky	6,381,144	3,747,724	544,286	4,292,010			
Tennessee and Georgia.	6,313,249						
Alabama	20,068,074	5,234,937	599,130	5,834,067			
Western Kentucky	10,249,480	293,539		293,539			
	327,730,942	98,807,985	23,187,147	121,995,132	42,519,765	12,478,045	54,997,810

[a] Western Pennsylvania includes the Pittsburgh, Westmoreland, Latrobe, Ligonier, Greensburg, and Connellsville districts of Pennsylvania and the Panhandle district of West Virginia.

PREPARATION OF COAL USED IN THE MANUFACTURE OF COKE.

Coke for iron furnaces must be as free from ash and sulphur as possible. Dirty coals are therefore cleaned by washing before being charged into coke ovens, and in 1918 the coal so treated amounted to 15,579,051 tons. Of the quantity washed, 8,577,723 tons, or 55 per cent, was run of mine, and the remaining 45 per cent was slack. Two-thirds of the coal used for making coke in New Mexico and nine-tenths or more of that used in Alabama, Colorado and Tennessee, was washed; in Georgia and Washington it was all washed.

[1] Informal communication from C. C. Marvel, manager, section on by-product coke and artificial gas plants, United States Fuel Administration, Nov. 22, 1918.

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In some of the coal fields the slack is screened out and used in making beehive coke, and the lump coal is shipped to market. The total quantity of slack used in 1918 was 13,154,000 tons, more than half of which was washed. The by-product ovens generally use run of mine coal of the best quality, and practically all the coal made into coke in ovens of that type, outside of Alabama, Colorado, Washington, and Tennessee, was unwashed run of mine coal. In New York also some coal used in by-product ovens is washed. In 1918 the proportion washed was 16.4 per cent.

The gradual change from beehive to by-product ovens is having its effect on the preparation of coal used in making coke. The proportion of washed coal has steadily decreased from 21.4 per cent in 1915 to 19.5 per cent in 1916, 18.5 per cent in 1917, and 18.3 per cent in 1918. The quantity of slack used has likewise been decreasing both relatively and absolutely. Of the coal charged in 1916, 17.9 per cent, or 14,611,000 tons, was slack; in 1917, 16.1 per cent, or 13,456,000 tons; and in 1918, 15.4 per cent, or 13,154,000 tons.

Coal used in the manufacture of coke in 1917 and 1918, by kinds, in net tons.

1917.

State.	Run of mine.		Slack.		Total.			
	Unwashed.	Washed.	Unwashed.	Washed.	Unwashed.	Percentage.	Washed.	Percentage.
Alabama	445,695	4,228,357	.....	2,964,789	445,695	5.8	7,193,146	94.2
Colorado	52,880	1,368,152	.....	363,599	52,880	3.0	1,731,751	97.0
Georgia	.....	.....	.....	72,689	.....	.....	72,689	100.0
Illinois	3,133,977	34,579	65,113	.....	3,199,090	98.9	34,579	1.1
Indiana	4,817,942	.....	.....	.....	4,817,942	100.0	.....	.....
Kentucky	941,106	.....	400,682	.....	1,341,788	100.0	.....	.....
Maryland	733,184	.....	.....	.....	733,184	100.0	.....	.....
Massachusetts	738,873	.....	.....	.....	738,873	100.0	.....	.....
Minnesota	495,508	.....	181,373	.....	676,881	100.0	.....	.....
New Jersey	621,699	.....	.....	.....	621,699	100.0	.....	.....
New Mexico	.....	.....	.....	936,411	.....	.....	936,411	100.0
New York	1,164,813	.....	4,769	231,876	1,169,582	83.5	231,876	16.5
Ohio	4,984,931	.....	381,067	.....	5,365,998	100.0	.....	.....
Pennsylvania	36,530,676	2,728,553	1,962,302	1,089,253	38,492,978	91.0	3,817,806	9.0
Tennessee	95,873	161,072	262	502,427	96,135	12.7	663,499	87.3
Virginia	1,003,138	.....	797,044	293,761	1,800,182	86.0	293,761	14.0
Washington and Utah	.....	160,550	670,492	45,025	670,492	76.5	205,575	23.5
West Virginia	3,022,995	70,094	2,121,057	267,948	5,144,052	93.8	338,042	6.2
Combined States [a]	2,761,229	.....	104,556	.....	2,865,785	100.0	.....	.....
	61,544,519	8,751,357	6,688,717	6,767,778	68,233,236	81.5	15,519,135	18.5

1918.

Alabama	431,444	4,478,461	.....	1,917,721	431,444	6.3	6,396,182	93.7
Colorado	51,365	1,240,081	.....	270,585	51,365	3.3	1,510,666	96.7
Georgia	.....	.....	.....	38,280	.....	.....	38,280	100.0
Illinois	3,077,518	19,400	102,702	.....	3,180,220	99.4	19,400	.6
Indiana	5,318,900	.....	.....	.....	5,318,900	100.0	.....	.....
Kentucky	880,324	.....	308,285	67,850	1,188,609	94.6	67,850	5.4
Maryland	696,576	.....	.....	.....	696,576	100.0	.....	.....
Massachusetts	676,866	.....	.....	.....	676,866	100.0	.....	.....
Minnesota	851,090	.....	218,685	.....	1,069,775	100.0	.....	.....
New Jersey	994,300	.....	.....	.....	994,300	100.0	.....	.....
New Mexico	.....	.....	394,964	652,711	394,964	37.7	652,711	62.3
New York	1,248,417	179,767	19,177	69,219	1,267,594	83.6	248,986	16.4
Ohio	7,569,702	.....	336,331	92,790	7,906,033	98.8	92,790	1.2
Pennsylvania	34,719,458	2,129,747	1,141,547	2,583,142	35,861,005	88.4	4,712,889	11.6
Tennessee	26,070	141,814	54,489	508,704	80,559	11.0	650,518	89.0
Virginia	884,174	.....	672,470	485,785	1,556,644	76.2	485,785	23.8
Washington	.....	154,460	.....	47,410	.....	.....	201,870	100.0
West Virginia	2,869,518	233,993	2,074,466	191,875	4,943,984	92.1	425,868	7.9
Combined States [a]	3,000,389	.....	829,800	75,256	3,830,189	98.1	75,256	1.9
	63,296,111	8,577,723	6,152,856	7,001,328	69,448,967	81.7	15,579,051	18.3

[a] Includes Michigan, Missouri, Oklahoma, Utah, and Wisconsin.

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YIELD OF COKE FROM COAL.

The yield of coke from coal varies with the coking time, the type of oven, the extent to which the coal used possesses the coking quality, and the analysis of the coal. The figures shown in the following table are averages obtained by dividing the total quantity of coke produced in each district by the total of the coal charged.

On the effect of the first of these factors, variation in the coking time, the records of the Survey throw no light.

The average yield from by-product ovens in 1918 was 70.5 per cent; the average yield in beehive ovens was reported at 63.3 per cent. The difference of 7.2 per cent in favor of the by-product process means an average recovery in by-product ovens of 144 pounds of coke more than the average in beehive ovens for every ton of coal charged. Had all the coke produced in 1918 been made in by-product ovens, the increased yield would have amounted to 3,466,000 tons.

This comparison, however, fails to do entire justice to the by-product oven in that it does not take into account the breeze produced. Data are lacking to compare accurately the total quantities of breeze formed in beehive and by-product coking, but it is possible to compare the quantities of breeze put to some use in the two industries, and the comparison is favorable to by-product practice. In addition to merchantable coke, the by-product operators in 1918 sold or utilized 1,999,370 tons of screenings or breeze. Beehive operators regarded as useful product only about 124,000 tons of the breeze formed. The recoveries of screenings and breeze at by-product plants in 1918 amounted to 108 pounds per ton of coal charged; at beehive plants the average quantity utilized was only 5 pounds. Expressed in terms of percentage of coal charged, the recoveries of useful breeze were 5.4 and 0.2 per cent for by-product and beehive ovens, respectively. Including the screenings and breeze, therefore, the recovery in useful form of solid carbon residue averaged 75.9 per cent in by-product ovens, as against only 63.5 per cent in beehive ovens, and it is a fair statement of fact that the coking of coal in beehive ovens in 1918, over and above the loss of the volatile products, cost the country 5,950,000 tons of solid fuel which would have been available had all the coal been treated in by-product ovens.

The table also discloses marked differences in the average recovery from one locality to another, irrespective of the type of oven. Thus into the average of 63.3 per cent for all beehive ovens went not only the maximum of 65 per cent in Pennsylvania but also the much lower figures of 53.6 per cent in Tennessee, 56.3 in Utah, 56.4 in Kentucky, and 57 in New Mexico. In general the yields in the Northern Appalachian region ran over 60 per cent. In the Southern Appalachian region and the Southwest the averages were less than 60 per cent. Of the western producers, only Colorado and Washington reported yields in excess of 60 per cent. These differences are attributable to the type of coal used. Not only do some coals coke more easily than others, but variation in the volatile content has a marked influence upon the percentage recovered. Thus the low-volatile coals of the Flat Top and Tug River districts of southern West Virginia, although possessing the coking quality to a high degree, gave an average yield in beehive ovens of only 59.3 per cent in 1918, whereas the higher-volatile coals of the Connellsville region

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yielded 66.3 per cent. The difference is caused in part by the fact that to provide the heat necessary for the beehive coking process, a considerable part of the fixed carbon in the lower-volatile coals is burned away. The combustion of the rich gaseous content of the high-volatile coals furnishes heat enough for the coking process with but little draft on the fixed carbon. From this fact it arises that the advantage of the by-product oven over the beehive oven is most pronounced when the coal used is a low-volatile coal.

Average yields in by-product practice ranged in 1918 from a minimum of 67.2 per cent in Ohio to a maximum of 82.2 per cent in Massachusetts. Variations in the mixture of coals used, in the coals themselves, and in coking practice, as well as in the type of oven, enter into these differences in yield.

The trend of the average recovery was steadily downward from 1915 to 1918, in both beehive and by-product practice as shown by the averages in the following tables. To what extent this was due to changes in the character of the coal used is uncertain. Many plants were forced during the war to use at times coal of unsatisfactory quality.

Average percentage yield of coke from coal in beehive and by-product ovens, 1915–1918.[a]

Year.	Beehive.	By-product.
1915	65.1	72.0
1916	64.4	71.9
1917	63.5	71.2
1918	62.3	70.5

[a] Screenings and breeze excluded in calculating the yield.

During the same period the average yields of certain of the by-products per ton of coal charged have also been decreasing.

Percentage yield of coke from coal in beehive and by-product ovens, 1914–1918.[a]

State.	1914		1915		1916		1917		1918	
	Beehive.	By-product.	Beehive.	By-product.	Beehive.	By-product.	Beehive.	By-product.	Beehive.	By-product.
Alabama	59.5	69.8	58.6	69.3	57.9	67.9	58.9	68.9	58.2	67.9
Colorado	63.5	.....	65.4	.....	62.9	.....	62.3	.....	62.4	69.5
Georgia	54.1	.....	58.6	.....	54.1	.....	54.5	.....	57.6	.....
Illinois	.....	73.8	.....	72.2	.....	72.9	.....	70.8	.....	71.4
Indiana	.....	72.8	.....	75.1	.....	75.4	.....	73.5	.....	73.3
Kentucky	63.0	70.2	61.6	71.5	61.4	71.6	55.3	71.6	56.4	73.9
Maryland	.....	67.6	.....	66.7	.....	65.3	.....	70.8	.....	74.3
Massachusetts	.....	76.4	.....	75.6	.....	77.3	.....	80.5	.....	82.2
Michigan	.....	74.1	.....	72.0	.....	71.9	.....	72.7	.....	75.9
Minnesota	.....	68.4	.....	70.7	.....	75.2	.....	72.4	.....	73.3
Missouri	.....	.....	.....	77.0	.....	76.9	.....	76.9	.....	75.2
New Jersey	.....	77.6	.....	77.0	.....	61.4	.....	68.1	.....	68.6
New Mexico	54.9	.....	53.1	.....	59.6	.....	61.7	.....	57.0	.....
New York	.....	69.3	.....	70.2	.....	70.6	.....	70.9	.....	70.5
Ohio	66.6	70.6	66.3	69.6	66.3	68.4	65.7	69.0	62.2	67.2
Oklahoma	.....	.....	.....	.....	.....	.....	.....	.....	58.2	.....
Pennsylvania	66.2	73.7	66.3	71.9	65.8	72.9	65.1	71.6	65.0	70.4
Tennessee	54.2	.....	53.9	72.5	54.5	76.7	54.0	55.3	53.6	74.9
Utah	55.9	.....	57.3	.....	55.0	.....	55.9	.....	56.3	.....
Virginia	59.2	.....	58.3	.....	62.8	.....	63.3	.....	60.4	.....
Washington	63.4	66.9	65.4	70.0	62.1	58.5	60.1	58.5	60.6	74.8
West Virginia	61.4	72.0	60.4	69.6	61.3	70.0	59.7	70.2	60.2	70.7
Wisconsin	.....	70.8	.....	70.3	.....	70.5	.....	72.9	.....	73.4
Average	64.6	72.4	65.1	72.0	64.4	71.9	63.5	71.2	63.3	70.5

[a] Screenings and breeze excluded in calculating the yield.

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DISTRIBUTION OF COKE.

SHIPMENTS OF BEEHIVE COKE, BY RAILROADS AND WATERWAYS.

The following tables, showing the quantity of beehive coke shipped by originating railroads and waterways in 1917 and 1918, are compiled from reports of the operators and therefore in some respects do not agree exactly with the records of the carriers themselves. As beehive ovens are almost invariably located at the mines, the great bulk of the beehive coke produced must be transported some distance in order to reach the place of use. In 1917 91.6 per cent of the entire output of beehive coke was loaded for shipment by rail or water; in 1918 the proportion was still higher, amounting to 93.8 per cent. In fact, in many localities, notably Georgia, Kentucky, New Mexico, West Virginia, and the far West, practically the entire output is shipped.

In other localities the furnaces that consume the coke are also located at the mines, and considerable quantities of coke produced are used locally without appearing as railroad shipments. This is notably true in Ohio, parts of Tennessee, and the Birmingham district of Alabama. In Pennsylvania also the local consumption is significant, the shipments ranging from 92.4 per cent of the output in 1917 to 87.5 per cent in 1918.

Water-borne shipments of beehive coke are confined to movement down Monongahela River from the Connellsville region. In 1917 shipments on the Monongahela were reported by the producers as 169,000 tons, or 0.6 per cent of the total output of beehive coke. In 1918 this movement increased more than tenfold and amounted to 1,839,000 tons, or 6.4 per cent. A striking feature of the statistics of rail shipments is the concentration of the movement over certain of the larger carriers. The five leading railroads—the Pennsylvania, Monongahela, Baltimore & Ohio, Norfolk & Western, and Pittsburgh & Lake Erie—together loaded about three-fourths of all the coke produced. This fact is taken advantage of by the Geological Survey in estimating the current production of beehive coke. Weekly statements obtained from 26 of the principal carriers, which load on the average 94 per cent of the entire output, are used as a base which is built up to terms of total production by allowing for shipments by water, shipments over the smaller roads, and the tonnage used locally. (For weekly and monthly estimates of production obtained in this way, see pp. 1453–1454.)

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Beehive coke shipped by originating railroads and waterways in the United States in 1917 and 1918, by States.

1917.

State.	Railroad.	Shipments (net tons).	Production (net tons).	Percentage of production shipped.
Alabama	Louisville & Nashville	615,206		
	Southern	496,026		
	Birmingham Southern, Alabama Great Southern, and St. Louis-San Francisco.	291,233		
		1,403,165	2,151,828	65.2
Colorado	Colorado & Southern	378,829		
	Denver & Rio Grande	135,281		
	Colorado & Southeastern, Colorado & Wyoming, and Atchison, Topeka & Santa Fe.	586,762		
		1,100,872	1,112,449	99.0
Georgia	Central of Georgia	39,589	39,589	100.0
Kentucky	Chesapeake & Ohio and Louisville & Nashville.	331,532	331,532	100.0
New Mexico	Atchison, Topeka & Santa Fe and El Paso & Southwestern.	577,679	577,679	100.0
Ohio			147,826	0.0
Pennsylvania	Baltimore & Ohio	2,774,681		
	Buffalo, Rochester & Pittsburgh	219,797		
	Ligonier Valley	268,742		
	Monongahela	5,630,456		
	Pennsylvania	11,026,867		
	Pittsburgh & Lake Erie	1,264,384		
	Buffalo & Susquehanna and Reynoldsville & Falls Creek.	463,099		
	Washington Run and Huntingdon & Broad Top Mountain.	242,008		
		22,010,034	23,816,420	92.4
Tennessee	Nashville, Chattanooga & St. Louis	85,372		
	Southern	89,413		
		174,785	376,080	46.5
Utah and Washington	Denver & Rio Grande and Northern Pacific.	471,187	471,187	100.0
Virginia	Norfolk & Western	383,843		
	Interstate	678,303		
	Southern and Louisville & Nashville	192,026		
		1,254,172	1,304,230	96.2
West Virginia	Baltimore & Ohio	284,410		
	Chesapeake & Ohio	232,476		
	Coal & Coke	196,237		
	Kanawha & Michigan	204,083		
	Morgantown & Kingwood	245,153		
	Norfolk & Western	1,684,580		
	Western Maryland	91,160		
		[a]2,851,099	2,838,728	100.4
Total railroad shipments		30,214,114		
Total waterways shipments (Monongahela River, Pennsylvania).		169,176		
Grand total		30,383,290	33,167,548	91.6

[a] 12,371 tons shipped from stock.

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Beehive coke shipped by originating railroads and waterways in the United States in 1917 and 1918, by States—Continued.

1918.

State.	Railroad.	Shipments (net tons).	Production (net tons).	Percentage of production shipped.
Alabama	Louisville & Nashville	477,870		
	St. Louis-San Francisco	75,924		
	Southern	468,809		
	Alabama Great Southern and Birmingham Southern.	144,804		
		1,167,467	1,717,721	68.0
Colorado	Colorado & Southern	258,156		
	Denver & Rio Grande	118,408		
	Atchison, Topeka & Santa Fe; Colorado & Southeastern; and Colorado & Wyoming.	382,202		
		758,766	758,784	100.0
Georgia	Central of Georgia	22,048	22,048	100.0
Kentucky	Chesapeake & Ohio	97,558		
	Ashland Coal & Iron and Louisville & Nashville.	203,101		
		300,659	301,036	99.9
New Mexico	Atchison, Topeka & Santa Fe and El Paso & Southwestern.	596,571	597,072	99.9
Ohio			138,909	
Oklahoma and Utah	Denver & Rio Grande and Kansas City Southern.	[a] 480,258	461,393	104.1
Pennsylvania	Baltimore & Ohio	2,111,688		
	Huntingdon & Broad Top Mountain	107,762		
	Ligonier Valley	288,437		
	Monongahela	4,171,002		
	Pennsylvania	10,562,147		
	Pittsburgh & Lake Erie	1,232,633		
	Buffalo & Susquehanna and Buffalo, Rochester & Pittsburgh.	557,017		
	Reynoldsville & Falls Creek and Washington Run.	332,409		
		19,363,095	22,136,664	87.5
Tennessee	Nashville, Chattanooga & St. Louis	80,140		
	Southern	70,864		
		151,004	302,637	49.9
Virginia	Interstate	663,660		
	Louisville & Nashville	138,356		
	Norfolk & Western	337,640		
	Norton & Northern and Southern	42,597		
		1,202,253	1,234,256	97.4
Washington	Northern Pacific	[b] 93,866	93,659	100.2
West Virginia	Baltimore & Ohio	496,109		
	Chesapeake & Ohio	265,717		
	Kanawha & Michigan	218,769		
	Morgantown & Kingwood	232,406		
	Norfolk & Western and Western Maryland.	1,321,991		
	Western Maryland	72,481		
		2,607,473	2,716,613	96.0
Total railroad shipments		26,743,460		
Total waterway shipments (Monongahela River, Pennsylvania).		1,839,167		
Grand total		28,582,627	30,480,792	93.8

[a] 18,865 tons shipped from stock.

[b] 207 tons shipped from stock.

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Beehive coke shipped by originating railroads and waterways in the United States in 1917 and 1918, by routes.

1917.

Route.	State.	Quantity (net tons).	Total (net tons).	Percentage of total.
Railroads:				
Alabama Great Southern, Birmingham Southern, and St. Louis-San Francisco.	Alabama	291,233	291,233	1.0
Atchison, Topeka & Santa Fe and El Paso & Southwestern.	Colorado and New Mexico	655,692	655,692	2.2
Baltimore & Ohio	Pennsylvania	2,774,681	3,059,091	10.1
	West Virginia	284,410		
Buffalo & Susquehanna, Huntingdon & Broad Top Mountain, and Washington Run.	Pennsylvania	646,391	646,391	2.1
Buffalo, Rochester & Pittsburgh	do	219,797	219,797	.7
Central of Georgia	Georgia	39,589	39,589	.1
Chesapeake & Ohio	Kentucky	131,224	363,700	1.2
	West Virginia	232,476		
Coal & Coke	do	108,237	108,237	.4
Colorado & Southeastern and Colorado & Wyoming.	Colorado	508,749	508,749	1.7
Colorado & Southern	do	378,829	378,829	1.2
Denver & Rio Grande and Northern Pacific.	Colorado, Utah, and Washington.	606,468	606,468	2.0
Interstate	Virginia	678,303	678,303	2.2
Kanawha & Michigan	West Virginia	204,083	204,083	.7
Ligonier Valley	Pennsylvania	268,742	268,742	.9
Louisville & Nashville	Alabama	615,906	924,743	3.0
	Kentucky	200,308		
	Virginia	108,529		
Monongahela	Pennsylvania	5,620,456	5,620,456	18.5
Morgantown & Kingwood	West Virginia	246,153	246,153	.8
Nashville, Chattanooga & St. Louis	Tennessee	85,372	85,372	.3
Norfolk & Western	Virginia	383,843	2,068,423	6.8
	West Virginia	1,684,580		
Pennsylvania	Pennsylvania	11,026,867	11,026,867	36.2
Pittsburgh & Lake Erie	do	1,364,384	1,364,384	4.5
Reynoldsville & Falls Creek	do	88,716	88,716	.3
Southern	Alabama	496,026	668,936	2.2
	Tennessee and Virginia	172,910		
Western Maryland	West Virginia	91,160	91,160	.3
Total railroad shipments		30,214,114	30,214,114	99.4
Waterways:				
Monongahela River	Pennsylvania	169,176	169,176	.6
Grand total		30,383,290	30,383,290	100.0

1918.

Railroads:				
Alabama Great Southern and Birmingham Southern.	Alabama	144,804	144,804	0.5
Ashland Coal & Iron and Norton & Northern.	Kentucky and Virginia	18,880	18,880	.1
Atchison, Topeka & Santa Fe and El Paso & Southwestern.	Colorado and New Mexico	639,989	639,989	2.2
Baltimore & Ohio	Pennsylvania	2,111,688	2,607,797	9.1
	West Virginia	496,109		
Buffalo & Susquehanna and Buffalo, Rochester & Pittsburgh.	Pennsylvania	557,017	557,017	1.9
Central of Georgia	Georgia	22,048	22,048	.1
Chesapeake & Ohio	Kentucky	97,558	363,275	1.3
	West Virginia	265,717		
Colorado & Southeastern and Colorado & Wyoming.	Colorado	338,834	338,834	1.2
Colorado & Southern	do	258,156	258,156	.9
Denver & Rio Grande and Kansas City Southern.	Colorado, Oklahoma, and Utah.	598,666	598,666	2.1
Huntingdon & Broad Top Mountain	Pennsylvania	107,762	107,762	.4
Interstate	Virginia	683,660	683,660	2.4
Kanawha & Michigan	West Virginia	218,769	218,769	.8
Ligonier Valley	Pennsylvania	288,437	288,437	1.0
Louisville & Nashville	Alabama	477,870	802,630	2.8
	Kentucky and Virginia	324,760		
Monongahela	Pennsylvania	4,171,002	4,171,002	14.6
Morgantown & Kingwood	West Virginia	232,406	232,406	.8
Nashville, Chattanooga & St. Louis	Tennessee	80,140	80,140	.3
Norfolk & Western	Virginia	337,640	1,659,631	5.8
	West Virginia	1,321,991		

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Beehive coke shipped by originating railroads and waterways in the United States in 1917 and 1918, by routes—Continued.

1918—Continued.

Route.	State.	Quantity (net tons).	Total (net tons).	Percentage of total.
Railroads—Continued.				
Northern Pacific	Washington	98,866	98,866	0.3
Pennsylvania	Pennsylvania	10,562,147	10,562,147	36.9
Pittsburgh & Lake Erie	do	1,232,633	1,232,633	4.3
Reynoldsville & Falls Creek and Washington Run	do	332,409	332,409	1.2
St. Louis-San Francisco	Alabama	75,924	75,924	.3
Southern	do	468,869	580,147	2.0
	Tennessee and Virginia	111,278		
Western Maryland	West Virginia	72,481	72,481	.3
Total railroad shipments		26,743,460	26,743,460	93.6
Waterways:				
Monongahela River	Pennsylvania	1,839,167	1,839,167	6.4
Grand total		28,582,627	28,582,627	100.0

FOREIGN TRADE IN COKE.

The foreign trade of the United States in coke, although modest in comparison with the 7,100,000 net tons exported from pre-war Germany, is an appreciable item in our foreign commerce. The give-and-take of trade makes of the United States both an importer and an exporter of coke. The balance, however, is heavily on the side of the exports, which in 1918 exceeded the imports by 1,658,000 tons, equivalent to 2,600,000 tons of coal. This was less than 0.5 per cent of the production of coal for the year, but about 9 per cent of the net exports of coal in all forms.

Before the outbreak of the World War our exports of coke averaged about a million tons a year. The war caused a temporary depression in the export movement, which gave place late in 1915 to a rapid expansion that carried the total exports to 1,175,000 tons in 1916, 1,409,000 tons in 1917, and 1,688,000 tons in 1918. The value of the exports in 1918 was $11,861,000.

The great bulk of our export coke goes to Canada and Mexico. In 1918 those two countries together took 92 per cent of the total exported. The 1,200,000 tons supplied to Canada went almost entirely to Ontario and lower Quebec, most of it by rail through Buffalo and Detroit. The volume of this export movement to Canada is often overlooked by the coal trade. These shipments in 1918 represented a coal equivalent of 1,870,000 tons, no mean item even when compared with the 5,000,000 tons of anthracite and 18,000,000 tons of raw bituminous coal exported to Canada.

Shipments of American coke to Mexico have averaged in recent years about a third of a million tons. The shipments in 1918 are reported at 359,744 tons, valued at $2,648,599. They were destined largely for lead and copper smelters in northern Mexico and left the United States through the customs districts of Arizona, San Antonio, and El Paso.

Sea-borne exports of coke from the United States are small and confined exclusively to the Atlantic and Gulf coasts. The principal port of shipment is Baltimore, from which in 1918 a total of 92,188 tons was forwarded. Occasional cargoes of coke are exported from

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Hampton Roads, Philadelphia, and Florida ports. Water-borne exports of coke go almost entirely to South America, there to be used in metallurgy. Among the South American Republics Chile ranks first as a purchaser of American coke, followed in order by Peru, Cuba, Argentina, and Brazil.

From the table of exports, by months, it will be noted that the foreign shipment of coke is fairly regular, displaying no pronounced seasonal rhythm.

Imports of coke, which ran about 125,000 tons a year before the World War, have now shrunk to insignificant proportions. In 1918 the imports were 30,168 tons, valued at $221,880. Most of the coke imported comes from British Columbia and is used by metallurgical works in Montana and Idaho. Occasional shipments are received from Ontario through the port of Buffalo.

Coke exported from the United States, 1909–1918.

Year.	Quantity (net tons).	Value.	Year	Quantity (net tons).	Value.
1909	1,002,916	$3,282,673	1914	663,585	$2,283,686
1910	984,618	3,053,203	1915	886,509	3,092,496
1911	1,023,727	3,215,990	1916	1,174,645	4,202,236
1912	912,576	3,002,742	1917	1,409,336	8,543,746
1913	987,396	3,309,980	1918	1,687,824	11,981,406

Coke exported from the United States in 1916–1918, by customs districts.

District.	1916		1917		1918	
	Quantity (net tons).	Value.	Quantity (net tons).	Value.	Quantity (net tons).	Value.
Alaska			3	$60		
Arizona	166,896	$564,896	148,041	704,714	194,461	$1,316,039
Buffalo	502,862	1,273,137	417,807	2,094,284	579,372	3,338,643
Dakota	7,711	30,137	6,446	49,206	2,635	23,289
Duluth-Superior	1,654	6,528	1,446	12,910	617	5,406
Eagle Pass	4,247	14,845	3,663	15,608		
El Paso	6,199	38,292	4,262	23,530	41,763	288,890
Florida	99	438	105	1,291	5,406	33,715
Laredo	17,494	60,490	85,781	622,243		
Maine and New Hampshire	15	73	1,027	10,512	1,680	12,131
Maryland	105,811	557,763	125,236	1,317,819	92,188	726,709
Michigan	124,348	522,963	233,465	1,629,990	376,083	3,202,783
Mobile					30	640
New Orleans	1,378	8,637	1,468	22,570	1,512	35,477
New York	21,137	147,011	24,518	232,305	13,719	183,543
Ohio	49,232	110,727	232,266	763,996	178,264	970,160
Philadelphia	20,208	104,296	5,000	56,985	4,280	44,697
Porto Rico			6	183	6	186
Rochester	8,296	23,814	11,245	42,457	6,257	53,238
Sabine	11	114	28	362	21	336
San Antonio					122,289	1,011,297
St. Lawrence	24,810	104,531	44,634	313,311	37,794	222,173
San Francisco	7,679	98,759	10,307	122,296	148	4,184
South Carolina	5,426	26,183				
Southern California	609	2,575	249	5,613		
Vermont	411	1,431	9,785	64,369	5,089	53,186
Virginia	44,657	222,808	18,915	197,662	8,401	91,743
Washington	53,390	263,879	32,563	188,905	15,789	133,274
	1,174,645	4,202,236	1,409,336	8,543,746	1,687,824	11,981,406

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Coke exported from the United States in 1916–1918, by countries.

Country.	1916		1917		1918	
	Quantity (net tons).	Value.	Quantity (net tons).	Value.	Quantity (net tons).	Value.
Argentina	7,230	$41,619	2,690	$39,701	4,585	$57,646
Azores and Madeira Islands			280	6,194		
Barbados	353	1,966				
Bermuda	1	10	7	49	112	2,800
Bolivia			827	5,899		
Brazil	2,398	22,312	1,393	23,429	1,519	10,969
British Guiana			11	282		
British Honduras	31	123	6	126	4	90
British South Africa			2	44	17	420
Canada	772,523	2,336,182	981,671	5,170,002	1,200,002	8,085,424
Chile	85,445	413,370	91,274	853,837	78,309	602,913
Colombia	82	645	64	1,638	74	1,570
Costa Rica	93	831	1,158	4,131	50	1,400
Cuba	12,450	57,198	8,761	85,106	14,162	147,522
Danish West Indies	3	37	7	165	8	231
Dominican Republic	57	603	38	725	105	1,637
Dutch East Indies	908	6,472	263	5,859		
Dutch West Indies	3	28				
Ecuador	58	547	87	1,264	111	1,925
England	8,695	50,258	3,395	29,888	33	371
France	8,242	47,021	10,403	80,028	7,997	79,940
French West Indies	56	431	215	3,701	214	4,955
Greece	2,752	16,498	373	4,995		
Guatemala	186	1,070	78	1,161	48	1,102
Haiti					6	135
Honduras	14	90	25	280	16	315
Italy	27,748	132,585	5,796	68,215	881	15,850
Jamaica	85	631	1	30	2	38
Other British West Indies					4	106
Mexico	205,388	808,772	265,982	1,541,753	359,744	2,648,599
Nicaragua	11	119	6	135	11	275
Norway	1,515	12,184	2,336	20,755		
Panama	711	4,911	2,000	33,317	848	22,318
Peru	25,049	179,711	33,854	501,483	18,646	165,830
Philippine Islands			163	6,522	78	2,290
Portugal	1	6	1	27		
Russia in Asia	67	494				
Russia in Europe	22	160				
Salvador	151	1,537	71	869	117	3,059
Spain	7,158	35,826	5,784	48,393		
Switzerland	1,128	6,548				
Trinidad and Tobago	18	128	53	985		
Uruguay	499	2,809	25	520	84	756
Venezuela	3,519	18,504	220	2,238	37	922
	1,174,645	4,202,236	1,409,320	8,543,746	1,687,824	11,861,408

Coke exported from the United States, 1916–1918, by months, in net tons.

Month.	1916	1917	1918	Total.	Three-year average.
January	101,797	93,714	94,910	290,421	96,807
February	98,689	88,591	93,809	281,089	93,697
March	105,257	145,688	158,158	409,103	136,368
April	93,686	89,330	157,923	340,939	113,646
May	102,085	150,181	164,349	416,615	138,871
June	100,615	171,302	158,137	430,054	143,351
July	64,262	58,985	182,949	286,196	95,399
August	90,669	120,934	147,561	359,164	119,721
September	107,689	98,641	148,459	354,139	118,046
October	93,508	127,696	133,052	354,256	118,085
November	103,102	79,607	164,245	347,044	115,681
December	113,936	184,561	104,272	402,769	134,256
	1,174,645	1,409,320	1,687,824	4,271,789	1,423,928

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Coke imported into the United States in 1916–1918, by customs districts.

District.	1916		1917		1918	
	Quantity (net tons).	Value.	Quantity (net tons).	Value.	Quantity (net tons).	Value.
Arizona			65	$309	272	$1,280
Buffalo	7,739	$34,478	6,720	41,065	9,218	67,355
Eagle Pass	1,053	2,855				
Maine and New Hampshire	215	853	394	2,352	575	4,513
Michigan	45	114	3,483	15,575		
Montana and Idaho	38,471	176,276	[a] 14,117	[a] 86,788	19,119	141,105
New York			6	99		
Oregon	28	100				
St. Lawrence			3	39	225	2,830
San Francisco	7,317	34,591				
Vermont	87	247	84	224	602	4,494
Washington					67	308
	54,955	249,514	24,872	146,451	30,168	221,880

[a] Montana only.

Coke imported into the United States in 1917 and 1918, by countries.

Country.	1917		1918	
	Quantity (net tons).	Value.	Quantity (net tons).	Value.
Canada	24,801	$146,043	29,894	$220,880
Mexico	65	309	272	1,220
England	6	99		
Japan			2	80
	24,872	146,451	30,168	221,880

Coke imported and entered for consumption in the United States, 1908–1918.

Year.	Quantity (net tons).	Value.	Year.	Quantity (net tons).	Value.
1908	147,427	$806,294	1914	133,226	$551,104
1909	191,253	736,120	1915	53,222	222,383
1910	172,716	625,130	1916	54,955	249,514
1911	77,923	254,455	1917	24,872	146,451
1912	123,614	488,308	1918	30,168	221,880
1913	101,212	435,157			

COKE BREEZE.

In the manufacture of coke a certain amount of fines not suited for foundry or furnace use and but little in demand as a domestic fuel is inevitably produced. This material, known to the trade as breeze, was defined by the Fuel Administration as follows, irrespective of whether produced in beehive or by-product ovens or in coal-gas retorts: (*a*) All small coke that is left after loading coke into cars by means of forks if disposed of without further screening or sizing, (*b*) any portion of this coke that remains after removing the prepared sizes, (*c*) any undersized coke that is left after removing the metallurgical coke, the foundry coke, or the prepared sizes by screening.

The characteristics of breeze are fine texture, high ash content (sometimes 20 per cent or more), and low density. Although containing considerable heat units per pound and burning without smoke, it can be used to advantage only on specially constructed grates.

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It is essentially a low-grade fuel presenting much the same problem as steam sizes of anthracite.

It has in the past been frequently proposed to utilize breeze as a raw material for fuel briquets, and at least two plants in the United States have made the attempt on a commercial scale. The first was a plant of the United Gas Improvement Co. at Point Breeze, Philadelphia, which was operated primarily to utilize the breeze produced at the retorts of the company's coal-gas plant. The briquets were used in the associated water-gas plant, and no attempt was made to sell them on the open market. Another briquetting plant designed to operate on coke breeze was constructed by the Semet–Solvay Co. at Delray, Mich. The briquets were designed for household use. At this plant, as at the Philadelphia plant, the breeze was mixed with bituminous coal slack. Neither plant made a commercial success of the breeze briquets, chiefly because of the injurious effect of the breeze on the bearings and other parts of the machinery. At the United Gas Improvement plant breeze was abandoned in 1909, and anthracite fines used instead. The operations at the Delray plant were also short-lived, the latest production reported being in 1909.

The abrasive character of coke breeze has continued to militate against its use for fuel briquetting and, so far as is known to the Geological Survey, no plant in the United States is employing it for this purpose at the present time.

A limited market for coke dust is found in the zinc-smelting industry, where it is used as a reducing agent in the clay retorts.

No accurate measure exists of the total quantity of breeze formed each year in the manufacture of beehive coke. The fines produced in beehive coking are given by Fulton as from 2 to 3 per cent in the Connellsville region, and Eavenson states that 5 to 8 per cent is common in the Pocahontas field. Parker in 1909 estimated the total quantity of fines as at least 2,000,000 tons a year. For the most part breeze has been treated by the beehive operator as so much waste matter and allowed to accumulate in piles or dumps in the manner of the old anthracite culm banks. Under the stimulus of the high prices which have prevailed since 1916 these old dumps have been reworked to some extent. Containing originally many fragments of a size large enough for domestic use, the old breeze piles have furnished limited quantities of domestic fuel. The practice assumed sufficient proportions during the war to be made the subject of special orders of the Fuel Administration which prohibited the reclaiming of old breeze dumps except under permit from the coke bureau of the Fuel Administration. This action was taken on the ground that (*a*) labor was being diverted from the production of fresh coke urgently needed for the manufacture of munitions, and (*b*) the transportation system, already overtaxed, was being burdened with the task of hauling a low-grade fuel. The maximum price allowed for such mixed domestic coke as was reclaimed from breeze dumps under permit issued in conformity to this order was $5.50 a ton. The maximum price permitted on coke breeze itself was one-half the price fixed for blast-furnace coke in the same district or in the Connellsville region, a maximum of $3 per net ton of breeze f. o. b. ovens. How much breeze was actually sold at this maximum does not appear.

In an effort to ascertain the quantity of breeze formed each year, the Geological Survey added to its beehive-coke schedule in 1918 an

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inquiry asking for the "quantity of screenings and breeze produced." From the replies it is clear that by no means all the fines formed in the manufacture of beehive coke were reported. Many operators reported no breeze at all, and those that did report generally mentioned small quantities. It seems clear that beehive operators as a class are not yet accustomed to think of breeze as a "product" or even as a by-product, but rather regard it as so much waste. The total quantity of breeze and screenings reported as produced at beehive ovens in 1918 was 124,000 tons, most of it from Pennsylvania. This is believed to represent breeze that brought some return to the operator or was used by him about the plant. The figures are published for what they are worth in the table on page 1494.

At retort coke ovens, on the other hand, breeze is now a recognized by-product. The majority of by-product plants are close to centers of population in which there is an expanding demand for both household and industrial fuel. Moreover, the operation of the by-product plant itself and of the iron and steel works commonly associated with it offers many opportunities for the utilization of breeze. It may be used as a boiler fuel to provide power, heat, or process steam. So numerous are the demands for boiler fuel about a typical by-product iron and steel plant that there is little incentive to dispose of the breeze on the open market.

The Geological Survey has collected statistics of breeze at by-product plants covering the last three years. The first of the accompanying tables presents data for 1916 and 1917. In those years the inquiry was so phrased as to ask for "breeze obtained and sold." The companies were requested to treat as sales the quantity used about the by-product plants or delivered to associated iron and steel works, and to assign a cost-keeping value to the breeze so used. The value was necessarily arbitrary but is still significant. The returns indicate a total credit derived from breeze and applicable to the expenses of the coking operations amounting to $1,700,000 for the 1,031,000 tons of breeze reported in 1916. This was an average value of $1.65 a ton. In 1917 the quantity reported was 1,496,000 tons, valued at $2,348,000, or $1.57 a ton. How much of this represented sales on the open market is unknown.

The data collected in 1918 are shown in the second of the following tables. Instead of asking, as in 1917, for the quantity obtained and sold, the inquiry in 1918 asked for the quantity produced. The replies indicated a total recovery in the form of screenings or breeze of almost 2,000,000 tons, the distribution of which from State to State followed closely the output of by-product coke. The value of the breeze produced in 1918 is not known. The maximum price for breeze when sold was fixed by the Fuel Administration at one-half the price fixed for run of oven coke.

The statistics of breeze reveal an additional point of superiority of by-product ovens over beehive ovens not always realized. To the beehive industry breeze is still a waste product, seldom utilized. To the retort-oven operator it is one of many valuable by-products. The by-product industry not only saves the volatile constituents in the coal and secures a higher percentage yield of merchantable coke but it also puts to good use some 2,000,000 tons of solid fuel, or about 5 per cent of the coal carbonized, which in beehive practice would be thrown away.

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Coke breeze obtained at by-product coke plants, 1916 and 1917.

State.	1916		1917	
	Quantity (net tons).	Value.	Quantity. (net tons).	Value.
Alabama	118,541	$213,022	141,051	$290,317
Illinois	162,585	329,294	201,478	295,139
Indiana	177,405	504,624	207,253	303,082
Kentucky	15,573	(a)	17,797	(a)
Maryland	42,221	(a)	21,448	(a)
Michigan	(a)	(a)	(a)	(a)
Minnesota	6,629	(a)	24,563	(a)
New Jersey	53,730	(a)	50,462	(a)
New York	32,023	29,867	70,484	71,319
Ohio	94,672	48,727	272,310	450,741
Pennsylvania	181,371	188,132	299,643	392,505
Tennessee			15,106	(a)
Washington	3,411	(a)	3,339	(a)
West Virginia	8,294	(a)	9,947	(a)
Wisconsin	(a)	(a)	(a)	(a)
Combined States	124,375	386,390	160,664	545,100
	1,030,830	1,700,056	1,495,545	2,348,203

a Included under "Combined States."

Coke breeze produced at by-product coke plants, 1918, by States, in net tons.

Alabama	217,349	Ohio	505,438
Colorado	9,701	Pennsylvania	327,177
Illinois	187,698	Washington	5,314
Indiana	290,175	West Virginia	36,179
Kentucky	16,320	Michigan, Missouri, and Wisconsin	191,542
Maryland	46,336		
Minnesota	38,054		1,999,370
New Jersey	74,725		
New York	53,362		

BY-PRODUCTS OBTAINED IN THE MANUFACTURE OF COKE.

The war-time demand for the by-products of coal carbonization lent a powerful stimulus to the development of by-product coking in America, and the expansion was not confined to the United States, for Canada also built new by-product plants. In the four years from 1915 to 1918 the output of by-product coke in the United States increased more than in the two decades from the building of the first by-product oven at Syracuse to the outbreak of the World War. The war period was not only marked by a great activity in the building of retort ovens, but also by the recovery on a large scale of a whole new set of valuable products—the light oils and derivatives—which had hitherto been left in the gas, although extracted in small quantities from the tar. The extraction of these new products—sold at prices that reached 15 times the pre-war level—was the chief cause of the extraordinary increase in the value of by-products of coke manufacture—from $17,000,000 total value of by-products produced in 1913 to $75,000,000 value of by-products sold in 1918.

AVERAGE YIELD OF BY-PRODUCTS.

The quantities of the several by-products recovered per ton of coal vary with the efficiency of the recovery system, the quality of the coal, the coking time, and the relative emphasis on coke or on

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the volatile products as objectives in the carbonization process. In 1918 the average yield at all plants was as follows:

Average yield of by-products per net ton of coal charged in by-product ovens, 1918.

Coke	pounds..	1,410
Tar	gallons..	7.1
Ammonium sulphate (or equivalent)	pounds..	18.9
Light oil	gallons..	2.4
Gas:		
Total	cubic feet..	10,444
Surplus sold or used	do....	4,295
Burned in coking process	do....	5,720
Wasted	do....	429

These ratios of by-products recovered per ton of coal charged are considerably below the maximum attainable by the best practice under favorable conditions. There was great variation in the recoveries at individual plants. The tar extracted ranged from a minimum of 4.2 gallons to a maximum of 12.3 gallons; the ammonium sulphate from 10.6 to 24.9 pounds; the crude light oil from 0.3 to 4.6 gallons. The ratios are thus weighted averages of the actual recoveries with the existing plants and under the conditions prevailing in 1918. To some extent those conditions were abnormal, particularly in the first four months of the year. Operating time was irregular, coal supplies were uncertain, and it frequently happened that the coke plants were forced to take coal of inferior quality. In spite of these irregularities the average yield of ammonia and of light oil was, if anything, larger than in 1916 and 1917. The 1918 averages may be accepted as the best available indicator of what may be expected in the near future from the country's present equipment of by-product ovens. Improvement in practice and the gradual replacement of old with new plants should gradually raise these ratios nearer the level of the present best practice.

BY-PRODUCTS OBTAINED IN 1918.

A change in the form of inquiry used in collecting statistics for 1918 makes it difficult to compare the returns for that year with those for 1917 and earlier years. In 1918, for the first time, the production and sales were asked for separately, and the only figures representing value collected were those giving the value of the products sold, including coke and surplus gas used about the same establishment. From the results of the inquiry, shown in the following table, it will be seen that there is in many items a considerable difference between the quantity produced and the quantity sold, the latter being usually somewhat the smaller. The difference may be due to one of three causes: (1) Part of the product may be consumed about the works, as, for example, tar burned as fuel; (2) the product may be refined or used in some manufacturing process on the premises and the finished product sold, as, for example, crude light oil delivered to the benzol plant; (3) the product may be stored awaiting transportation or a favorable moment to sell. After the armistice was declared, for example, the prices of ammonia and the group of light oil products broke, and stocks were accumulated at most plants. Of course a rise in price may sometimes cause an opposite effect, with drafts on stocks and sales in excess of production for a given period.

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By-products obtained from coke-oven operations in 1918.

Products.	Production.	Sales.		
		Quantity.	Value.	Average value per ton.
Tar.....gallons..	263,299,470	200,233,002	$6,364,972	$0.032
Ammonia:				
Sulphate.....pounds..	436,388,134	423,515,836	19,061,777	.045
Anhydrous or free ammonia[a].....do....	65,230,159	61,442,983	7,381,174	.120
			26,442,951	
Gas:				
For illuminating and household purposes, M cubic feet.....	385,035,154	33,437,991	7,130,113	.213
For industrial purposes.....M cubic feet..		124,920,488	6,569,402	.053
			13,699,515	
Benzol products:				
Crude light oil.....gallons..	87,222,450	3,764,272	963,042	.256
Secondary light oil.....do....	339,644	121,191	15,472	.128
Benzol.....do....	44,804,900	43,441,980	11,966,367	.275
Toluol.....do....	8,861,948	8,541,306	12,249,702	1.434
Solvent naphtha.....do....	3,540,162	3,123,815	439,983	.141
Other oils.....do....	636,707	571,752	53,880	.094
			25,688,446	
Naphthalene, crude.....pounds..	10,614,799	10,403,758	287,581	.028
Refined.....do....	5,472,699	5,486,689	362,648	.066
			650,229	
Other products[b].....	.....	.....	1,756,345	.....
			74,602,458	

[a] Includes liquor and sulphate sold on pound basis of NH_3.
[b] Includes sodium ferrocyanide, pyridin oil, nut coke, drip oil, spent oxide, residue, coal tar paint, and wash oil.

The tar obtained in 1918 was reported as 263,299,470 gallons, an average recovery of 7.1 gallons per ton of coal charged. The quantity sold was 200,233,002 gallons, valued at $6,364,972, an average value of $0.032 a gallon. Coke-oven tar and its sister product coal-gas tar—obtained from coal-gas plants—are one source of the well-known "coal-tar derivatives." The bulk of the output is sold to refiners. The difference between production and sales—63,066,468 gallons—represents in part additions to stock, in part consumption as fuel, and in part crude tar treated on the premises in associated refining plants.

Ammonia recoveries in 1918 were reported partly as ammonium sulphate, partly as anhydrous ammonia. The total production in all forms amounted to 174,327,000 pounds expressed as anhydrous ammonia. The total output expressed in terms of ammonium sulphate amounted to 697,308,000 pounds. The exact quantity recovered in each form is not certain. Each producer was asked to state (1) pounds of ammonium sulphate produced; (2) gallons of ammoniacal liquor produced, giving average strength in per cent NH_3; (3) pounds of anhydrous or free ammonia produced, including the liquor and sulphate sold on pound basis of NH_3. In reply to the first of these questions a total of 436,388,134 pounds was reported, indicating that the production of sulphate as such amounted to at least that figure. No liquor was reported as such in reply to inquiry 2, but the total of

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65,230,159 pounds NH_3 given in answer to the third inquiry probably included the equivalent of a certain quantity of liquor, and also of ammonium sulphate; how much of each is unknown. The returns may be summarized in the statement that at least 63 per cent and possibly more of the output in 1918 was recovered in the form of sulphate.

Practically all the ammonia produced was sold, the small difference being largely attributable to additions to stock after the break in price, which occurred a little before the signing of the armistice. The total value of the ammonia sold, in all forms, was $26,442,951.

Equal in importance to the ammonia compounds as a source of auxiliary revenue was the group of benzol products. The washing of coke-oven gas to recover the "benzols" on a significant scale in the United States dates back to 1915, when the Allied war orders for munitions began to flow into this country. At that time comparatively few by-product plants were equipped with stills to refine their own crude light oil. By 1918, however, it had become the general practice to conduct at least the preliminary stage of refining on the premises. The production of crudes in 1918, including oil later refined, was 87,222,450 gallons of crude light oil and 339,644 gallons of secondary light oil, a total of 87, 562,094 gallons. Of this quantity 3,885,463 gallons (crude and secondary), or about 4 per cent of the production, was sold. The remaining 96 per cent was treated on the premises, yielding 44,804,900 gallons of benzol (crude and pure), 8,861,948 gallons of toluol (crude and pure), 3,540,162 gallons of solvent naphtha, and 636,707 gallons of xylol and other valuable oils. The residue unaccounted for by sales of crudes or recoveries of refined products amounts to about 6,400,000 gallons, or 7 per cent of the crudes produced. This is understood to represent in part naphthalene, in part additions to stocks, and in part unsalable products which are used about the plant or returned to the gas. Of the benzol and toluol produced practically all was sold, although as a result of the collapse of prices after the armistice was declared there were slight additions to stocks. Sales of solvent naphtha and other oils amounted to 89 per cent of the production.

The total revenue derived from the group of benzol products was $25,700,000, of which nearly half was contributed by toluol alone. The average price realized for all the toluol sold was $1.43 a gallon. Next to toluol in point of value came benzol itself, with total sales amounting to $11,966,000, an average of $0.28 a gallon. The naphthalene recovered in 1918 amounted to 16,088,000 pounds. Practically all of this was sold, much of it for the manufacture of moth balls. The proceeds of the sales were reported at $650,000. Two-thirds of the quantity sold was in the form of crude naphthalene, defined as having a solidifying point below 79° at an average value of 2.8 cents a pound. The refined naphthalene, solidifying at over 79°, sold on the average for 6.6 cents a pound, more than twice as much. Other minor products to the aggregate value of $1,756,000 were sold.

Second in value among the by-products to the ammonia group and the benzol group ranked surplus gas, of which sales amounting to $13,700,000 were reported in 1918.

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Disposition of the gas generated at by-product coke plants in 1918.

	M cubic feet.	Per cent.
Wasted	15,800,363	4.1
Burned in coking process	210,876,312	54.8
Surplus sold or used:		
For illuminating and household use	33,437,991	8.7
For industrial purposes	124,920,488	32.4
	385,035,154	100.0

The surplus 158,358,479,000 cubic feet available for use in other departments about the plant or for delivery to outside consumers is to be properly regarded as sales and should be credited to the operation of the by-product coke plant.

A tendency of recent developments in the by-product coke industry has been the construction of plants with retort ovens designed primarily to supply gas for city use. It is thus significant that approximately 33,000,000,000 cubic feet of by-product oven gas was delivered for illuminating and domestic use in 1918, at a total value of over $7,000,000, an average of $0.21 a thousand feet. This represents not the price to the consumer, but the average price realized by the producer, exoluding costs of distribution, etc. Although the quantity used for industrial purposes was nearly four times as great (124,920,000,000 cubic feet), the value placed upon it was slightly less than that of the illuminating and domestic gas, amounting to $6,569,000, or $0.053 a thousand. The low value per thousand feet reported for the industrial gas is explained by the fact that the great bulk of it is used in associated steel plants, to which it is supplied at nominal rates. The quantity of by-product gas used in 1918 in iron and steel manufacture is not known accurately, but it is probably about 120,450,000 M cubic feet.

Sales of all by-products in 1918 amounted to $74,602,000, or $2.87 for every ton of coke produced. This was far from being a net rebate on the costs of each ton of coke, however, for it represents gross revenue only, out of which must come all the expenses of by-product recovery. The gross contribution from each by-product was as follows, ranged in order of rank:

Receipts from sales of by-products per ton of coke produced, 1918.

Ammonia	$1.02
Benzol group	.99
Gas	.53
Tar	.24
Miscellaneous products	.09
Total by-products	2.87

These figures represent war-time prices, it must be remembered, which, especially for the benzol group, were much above normal. Under those prices ammonia leads as the most important by-product, assuming again a place which it had lost to the benzol products during 1916 and 1917.

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RELATION OF BY-PRODUCT COKE INDUSTRY TO THE ARTIFICIAL-GAS INDUSTRY.

The gas and other by-products obtained in by-product coking operations can be intelligently understood only if viewed in conjunction with the other sources of gas and of coal by-products.

Artificial gas is produced in the United States by a group of closely related industries. In addition to the surplus gas produced in the manufacture of by-product coke, which is available for domestic and industrial use, there are municipal gas plants that supply either coal gas, water gas, or oil gas, or a combination of two of them. These four kinds of gas have been treated in the statistics published by the Geological Survey as a common supply available to consumers of gas fuel. In addition, large quantities of producer gas and blast-furnace gas are produced annually, but as they are seldom sold outside the plants in which they are produced, no statistics concerning them have been collected.

The following table summarizes the consumption of artificial gas in recent years. For each item the measure of consumption is taken to be the quantity sold rather than the quantity produced.

Artificial gas consumed in the United States 1915–1918, by kinds.

	Quantity (M cubic feet).	Value.	Average value per M cubic feet.
1915.			
Coal gas	43,747,432	$40,257,108	$0.92
By-product gas	84,355,914	8,624,809	.10
Oil gas and water gas	138,100,902	124,950,125	.90
1917.			
Coal gas	42,927,728	38,324,113	.89
By-product gas	131,026,575	11,360,335	.09
Oil gas and water gas	168,196,826	145,346,976	.86
1918.			
Coal gas	42,659,487	42,846,964	1.00
By-product gas	158,358,479	13,609,515	.09
Oil gas and water gas	192,281,580	171,154,159	.90

The surplus gas of by-product coke ovens has thus become a material factor in the supply of gas fuel. In terms of cubic feet it amounted in 1918 to nearly four times as much as the coal gas sold and came within 16 per cent of the oil and water gas. Moreover, it is increasing in output more rapidly than either of the others. The sales of coal gas decreased slightly from 1915 to 1918, and those of oil and water gas increased only 37 per cent, but the sales of surplus coke-oven gas nearly doubled.

In the following table are given the sales of the principal by-products reported by the group of artificial-gas industries in 1918. For some products—for example, the naphthalene, ammonia, and retort carbon recovered from coal gas and by-product coke-oven gas—the sales are practically identical with the production. But for other by-products the sales may be much smaller than the output, because part of the output is used about the works. Thus tar, particularly water-gas tar, is often used as boiler fuel. Coal-gas tar is sometimes treated at the works for recovery of coal-tar derivatives. The carbon residue or lampblack obtained in the manufacture of oil gas may be used as boiler fuel at the plant or briquetted and sold as domestic fuel.

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For all these products the statistics of sales are of value because they give a measure of the surplus of each material placed on the market and therefore available for use by other industries. In the case of one group of by-products, however, the light oils or "benzol products," the figures of sales mean little except when studied in conjunction with statistics of production. As the source of benzol and toluol, the bases of the most important high explosives, the light oils received great attention during the war. Stripping plants to recover the light oils from the gas were erected at practically all by-product coke plants and at many municipal gas plants, and the production was greatly increased.

Light oil and other crudes produced in 1918, in gallons.

Crude light oil:	
By-product ovens	87,222,000
Water gas	15,924,000
Coal gas	5,914,000
Secondary light oil:	
By-product coke ovens	340,000
Water gas	9,000
Drip and holder oils:	
Water gas	3,365,000
Coal gas	117,000

The process of refining the crudes to recover benzol, toluol, and other fractions is sometimes conducted at the coke oven or gas plant and sometimes at central refining plants to which the crudes are shipped for treatment. The total production of pure benzol in 1918, from all sources, including petroleum oils, has been estimated at 44,000,000 gallons, and the production of pure toluol at about 14,000,000 gallons.

By-products of gas manufacture marketed in the United States in 1918.[a]

Product.	Quantity.	Value.
Tar (gallons):		
Coal gas	47,727,839	$1,868,580
Water gas	54,733,478	1,789,898
Oil gas	550,006	15,967
By-product	200,233,002	6,364,972
	303,244,325	10,034,417
Ammonium sulphate or equivalent (pounds):		
Coal gas	56,900,464	1,453,070
By-product	697,308,770	26,442,951
	754,209,234	27,896,021
Light oils (gallons): [b]		
Coal gas and water gas	12,347,288	6,992,987
Oil gas	20,376	4,274
By-product	59,564,376	25,688,446
	71,932,040	32,685,707
Naphthalene (pounds):		
Coal gas and water gas	896,080	14,282
By-product	15,890,447	650,229
	16,786,527	664,511
Retort carbon (short tons):		
Coal gas	1,007	13,275
Water gas	251	2,230
By-product	655	2,732
	1,913	18,237
Lampblack and carbon residue (short tons): [c]		
Oil gas	17,673	95,211

[a] Other products not included in this table, valued at $1,906,515 in 1918, were, from coal-gas plants, creosote, tar distillery products, pitch, coke breeze, and spent oxide; from oil-gas plants, yellow prussiate of soda; from by-product coke oven plants, coke breeze, sodium ferrocyanide, residue, drip oil, spent oxide, and pyridin oil.

[b] Including crude light oil, secondary light oil, benzol, toluol, solvent naphtha, and drip oils.

[c] Exclusive of briquets made from carbon residue.

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SCHEDULES USED IN 1918 CANVASS.

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DEPARTMENT OF THE INTERIOR

UNITED STATES GEOLOGICAL SURVEY

In cooperation with United States Fuel Administration

PRODUCTION OF BEEHIVE COKE IN 1918.

Please fill out replies to the following queries and return as promptly as possible in the inclosed envelope, which requires no postage. All replies are held confidential, individual figures not being divulged.

Name of operator.....
Address.....
Name of works.....
Location of works: Town.....
State..... County.....
Total number of beehive ovens in existence December 31, 1918.....
Total number of beehive ovens in course of construction December 31, 1918.....
Average number of ovens idle entire year.....
Number of ovens dismantled or otherwise permanently abandoned in 1918.....

Coal charged into ovens:	Net tons.	Value at ovens.
Run of mine unwashed	.....	$.....
Run of mine washed	.....	.....
Slack unwashed	.....	.....
Slack washed	.....	.....
Total charged	.....	$.....

Does quantity of washed coal represent the weight before or after washing?.....
If before, what is the average percentage of loss in washing?.....

	Net tons.	Value.		
Coke produced	.....	X	X	X
Screenings or breeze produced	.....	X	X	X
Coke sold:				
Furnace	.....	$.....		
Foundry	.....	.....		
Domestic and other	.....	.....		
Coke not sold but used by producer	.....	X	X	X

Value reported should be value at the works exclusive of selling expenses.

If coal charged into these beehive ovens is shipped in over a railroad, from what mines did it come?

.....
.....

On what railroads is coke loaded for shipment?

Roads.	Tons.
.....	.....
.....	.....
.....	.....
.....	.....
.....	.....

Please note the names and addresses of any new coke plants in your vicinity.

.....
.....
.....
.....

If you have recently acquired this plant, please give the name and address of the former owner or operator and the date on which you took possession.

.....
.....
.....
.....

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If you have sold or leased this plant, or surrendered your lease, please give the name and address of your successor and the date on which you gave possession.

.....
.....
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DEPARTMENT OF THE INTERIOR.

UNITED STATES GEOLOGICAL SURVEY.

In cooperation with United States Fuel Administration.

PRODUCTION OF COKE AND BY-PRODUCTS IN BY-PRODUCT OVENS—1918.

Please fill out replies to the following queries and return as promptly as possible in the inclosed envelope, which requires no postage. All replies are held confidential, individual figures not being divulged.

Name of operator.....
Address.....
Name of plant.....
Location of plant: Town..... State..... County.....
Total number of ovens in existence December 31, 1918 .....
Kind of ovens in existence..... .....
Total number of ovens in course of construction December 31, 1918..... .....
Kind of ovens building..... .....
Average number of ovens idle entire year..... .....
Number of ovens dismantled or otherwise permanently abandoned in 1918..... .....

Coal charged into ovens:	Net tons.	Value at ovens.
Run of mine unwashed.....	.....	$.....
Run of mine washed.....	.....	.....
Slack unwashed.....	.....	.....
Slack washed.....	.....	.....
Total charged.....	.....	$.....

Does quantity of washed coal represent the weight before or after washing?.....
If before, what is the average percentage of loss in washing?.. .....

	Net tons.	Value.
Coke produced.....	.....	x x x x x x x x
Screenings or breeze produced...	.....	x x x x x x x x
Coke sold:		
Furnace.....	.....	$.....
Foundry.....	.....	.....
Domestic and other.....	.....	.....
Coke not sold but used by producer.....	.....	x x x x x x x x

(Value reported should be value at the works exclusive of selling expenses.)

BY-PRODUCTS OBTAINED AND SOLD—1918.

(Value reported should be value at the works exclusive of selling expenses.)

	Production.	Sales.	Value at plant of sales.
	Gallons.	Gallons.	
Tar.....	.....	.....	$.....
Ammonia:	Pounds.	Pounds.	
Sulphate.....	.....	.....	.....
	Gallons.	Gallons.	
Liquor.....	.....	.....	.....
Strength of liquor (average).....			
Or report as—	Pounds.	Pounds.	
NH^3.....	.....	.....	$.....

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Gas:	Cubic feet.	Cubic feet.	
Produced	.....	x x x x x x x x x x x x	
Used in process	.....	x x x x x x x x x x x x	
Wasted	.....	x x x x x x x x x x x x	
Surplus gas sold or used:	Cubic feet.	Cubic feet.	
For illuminating and household work	x x x x x x	.....	$.....
For industrial work	x x x x x x	.....	.....
Light oil:	Gallons.	Gallons.	
Crude light oil	.....	.....	.....
Secondary light oil	.....	.....	.....
Benzol	.....	.....	.....
Toluol	.....	.....	.....
Solvent naphtha	.....	.....	.....
Other oils (specify)	.....	.....	.....
Naphthalene:	Pounds.	Pounds.	
Crude	.....	.....	.....
Refined	.....	.....	.....

(NOTE.—"Refined" is naphthalene that has a solidifying point of 79° centigrade or above. "Crude" is naphthalene that has a solidifying point below 79° centigrade.)

Other products:			
Exclusive of coke (specify)	.....	.....	.....
Total value of by-products sold			$.....

.....

(Sign here with title.)

REFERENCES TO THE COKE INDUSTRY CONTAINED IN THE REPORT OF THE DISTRIBUTION DIVISION OF THE U. S. FUEL ADMINISTRATION.

In the report of the distribution division of the United States Fuel Administration is to be found much information concerning the coke industry during the war period, particularly on the subjects of requirements and consumption. The report is published in three parts as follows: I, The distribution of coal and coke, by C. E. Lesher; II, The zone system, by Wayne P. Ellis; III, Statistical tables, by C. E. Lesher. Any part may be had upon application to the Director, United States Geological Survey. Appended is a list of references concerning coke contained in these reports.

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